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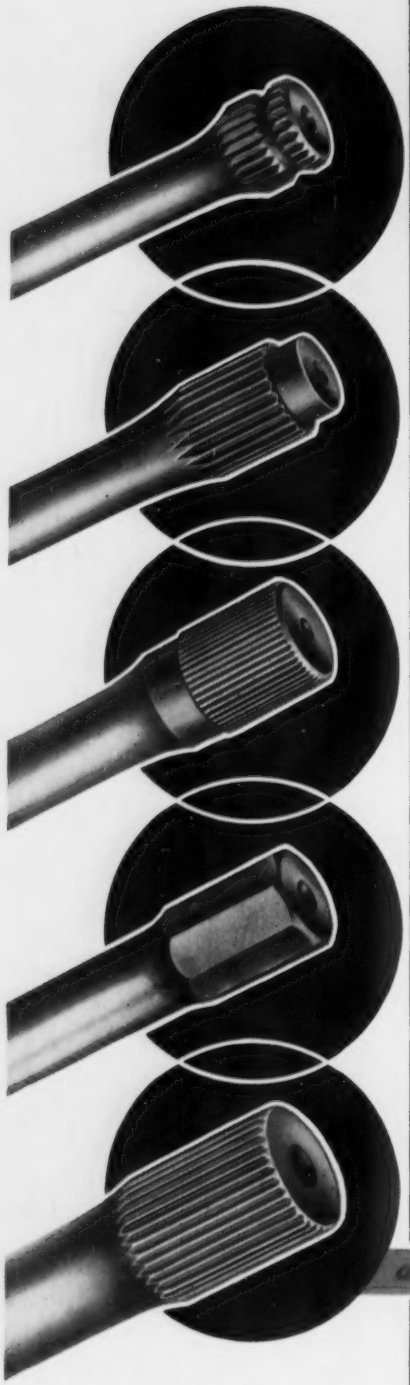

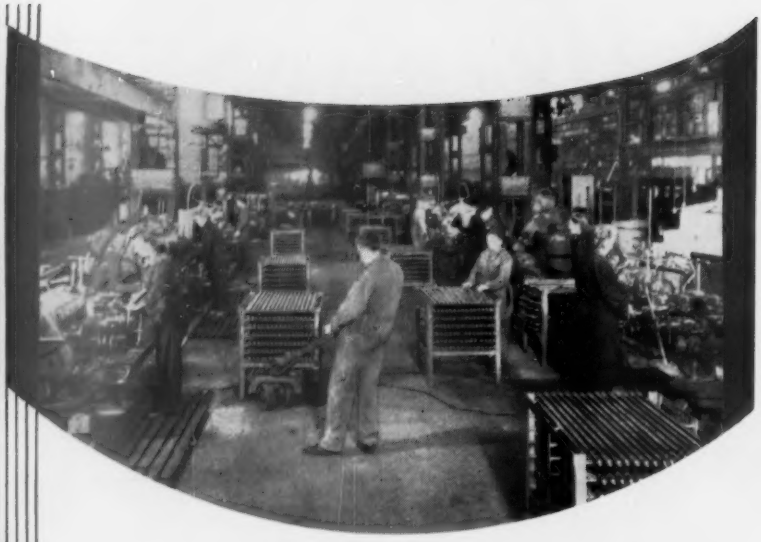

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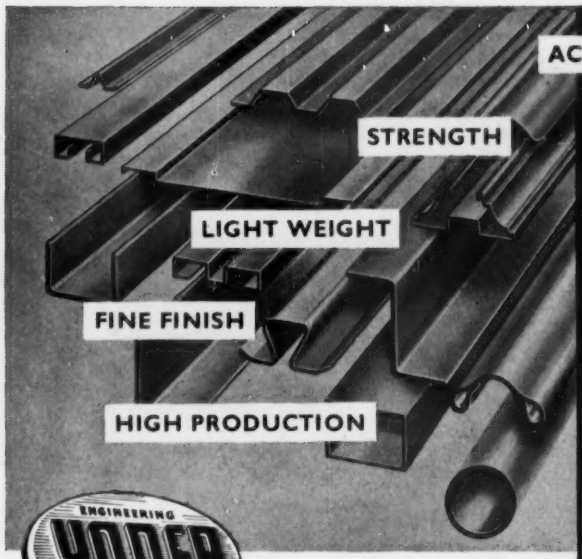

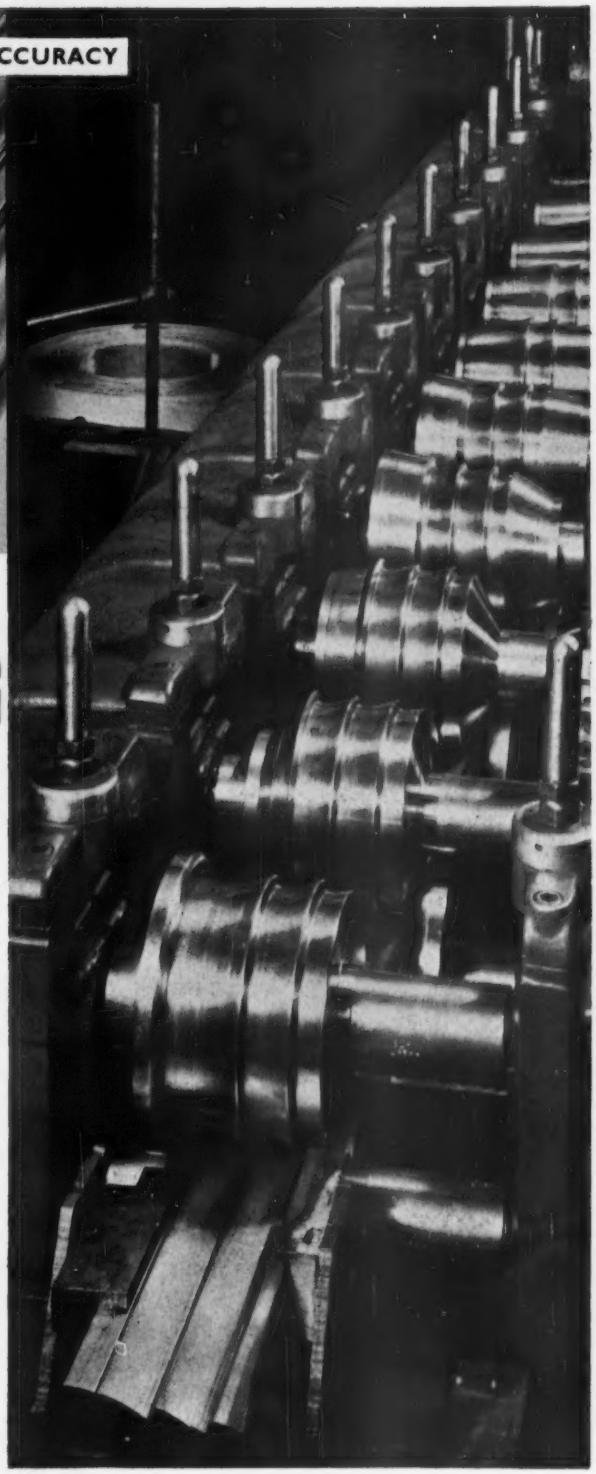

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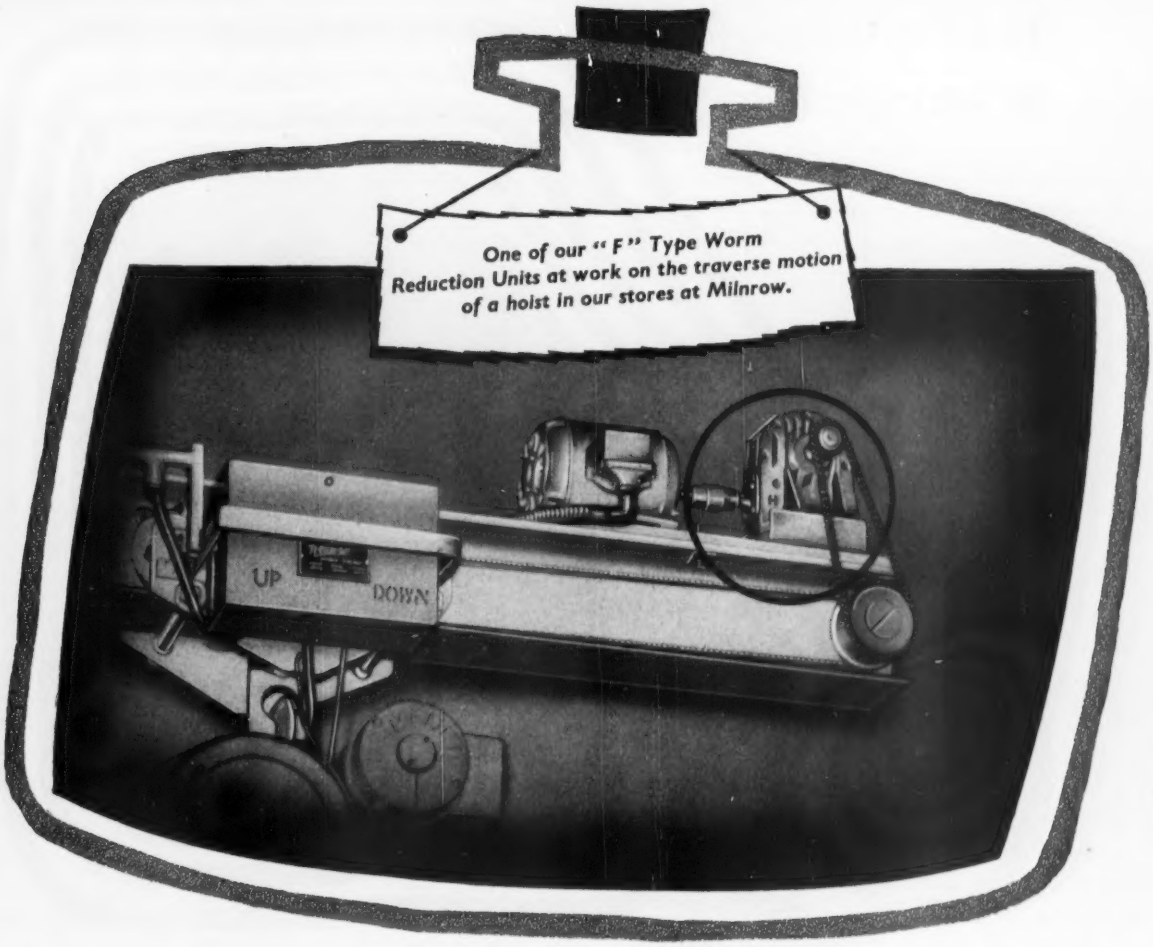

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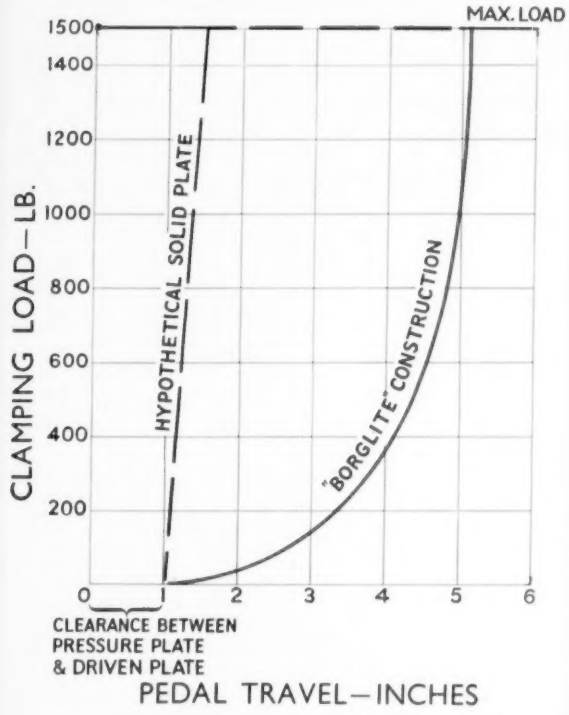
REVIEW

In the beginning of these notes, attention was drawn to the complexity of any transmission system. It was observed that not only does one part of that system react on other parts of it but that undesirable behaviour in a transmission can originate in components not normally regarded as belonging to it. Mention was made also of the fact that a transmission, unlike a power unit, cannot be isolated by such things as flexible mountings and it must therefore be as free as possible from vibration or similar disturbances.

Later essays described several examples of bad manners in transmission systems and indicated the causes of them. Judder, for instance, can arise from a fairly wide variety of sources. The list included a faulty sparking plug, excessive movement (axial or tangential) of the engine in its mountings, oscillation of the driving axle and even inadequate rigidity of the complete vehicle.



Rattle is a manifestation of two quite separate facts. One is the existence of clearance at some place or places in the transmission system, such as a splined joint, a dog clutch or between gear teeth. The other is the occurrence of load fluctuations or alternations at the point of clearance but almost invariably originating elsewhere. Since clearance is essential at certain places, rattle can be prevented only by avoiding torsional vibrations or other causes of cyclic variations of load.

Backlash is another trouble which arises from the presence of clearances but the effect of them here is quite different from rattle. When clearance is taken up or transferred from say the front of a gear tooth to the back, the driving member is necessarily revolving faster than the driven member. So, when the take-up is complete, there must be some shock. In the particular case of starting a car from rest, the whole series of clearances from end to end of the transmission may have to be reversed before the vehicle moves. Appreciable shaft speed is therefore probable before the system is loaded.

In such a case, the shock force depends largely upon the engine speed at the moment when the road-wheel resistance is felt. But backlash shock can occur also whenever the throttle is closed or opened with the vehicle in motion. Broadly, the magnitude of the shock varies with the shaft speed.

These three phenomena have one feature in common. In at least some of their manifestations they appear superficially to be clutch faults although in fact they arise elsewhere. In truth they are not among the sins of the clutch manufacturer.

Nevertheless the clutch is an important link in the transmission system and it does lend itself in certain ways to fight these three evils. Some discussion of these ways may help those concerned with vehicle design to realise what assistance they may expect from the clutch maker. And, by subtraction, so to speak, it may indicate where the vehicle designer must help himself.

Probably the most important feature of a clutch from this angle is its possession, when desired, of a spring centre driven plate. Precisely how this can be used to counter such troubles as rattle and judder is too long a story for the space remaining here and will be dealt with in the next article.

Meanwhile we may note that judder and back lash, in so far as they are concerned with clutch engagement, can be minimized by employing a clutch that gives particularly smooth engagement. In a Borglite plate, for instance, spring segments behind the friction facing ensure a very light initial pressure.

With this device, the relation between pedal travel and nett clamping force follows a curve instead of a straight line. In other words, the rate of engagement of the friction faces is not constant but is very low initially so that backlash is absorbed while the applied torque is still small. Useful though this is in its particular sphere, one must note that it has no effect on backlash or judder arising from events other than clutch engagement.

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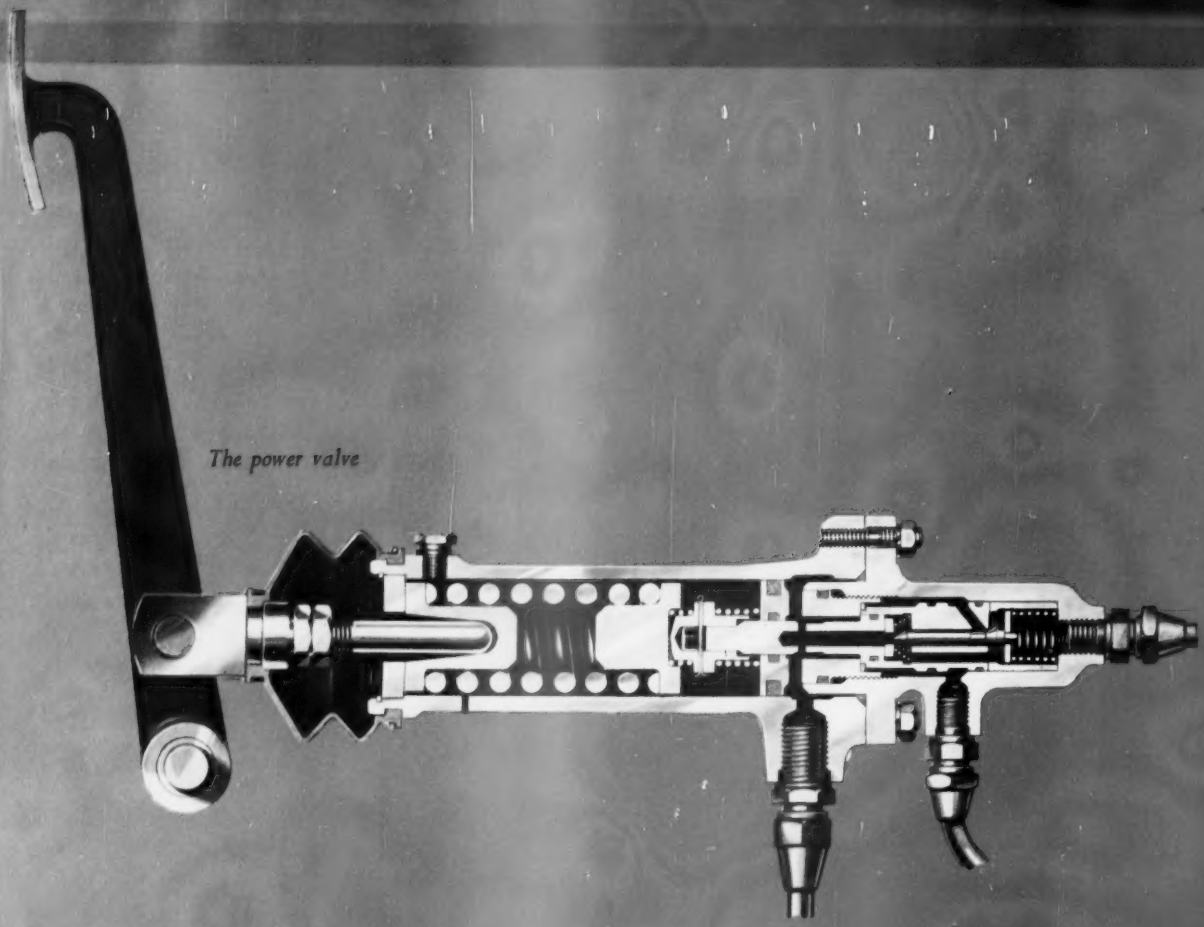
The power valve



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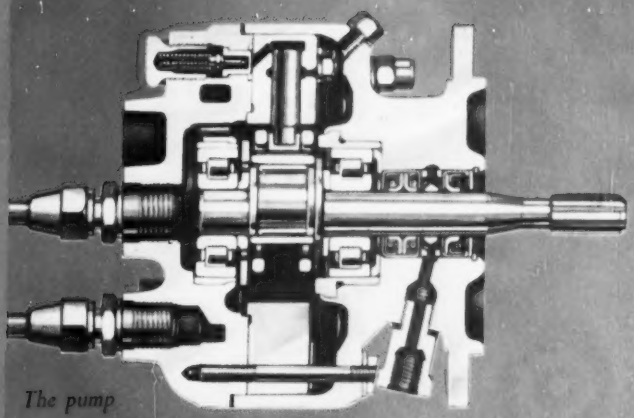
The special power valve is so arranged that for any given pedal pressure the same hydraulic pressure is passed to the brakes on every occasion. Moreover, this pressure is balanced in relation to the pedal pressure so that the driver retains the natural feel of the braking system and the servo system can never take charge.

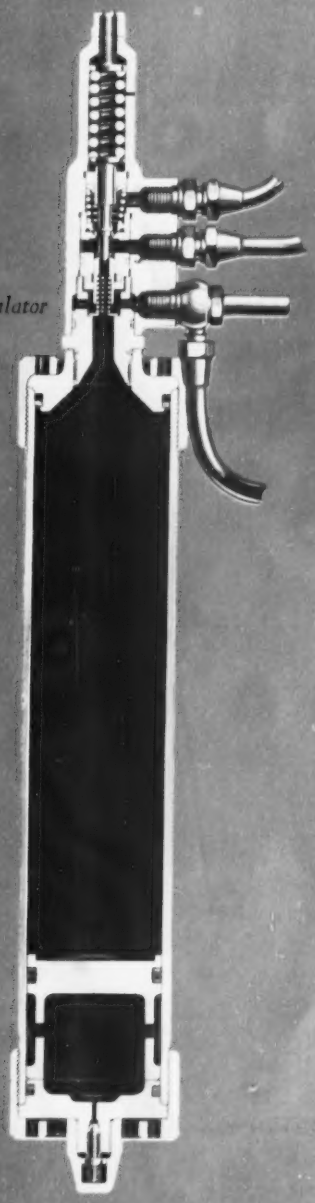
Lockheed



The pump

The cut-out operates when the reservoir is charged, after which the pump idles under no-pressure conditions, and the valve unit automatically diverts fluid under pressure to re-charge the accumulator when needed.

The Lockheed spring-type accumulator, or the piston-type accumulator as illustrated, is used, having combined with it the cut-out and accumulator charging valve.



The piston-type accumulator

The spring-type accumulator has sufficient power reserve for a number of brake actuations should the engine or vehicle stop, but where power door operation or power steering are required, the piston-type is employed owing to its greater capacity.

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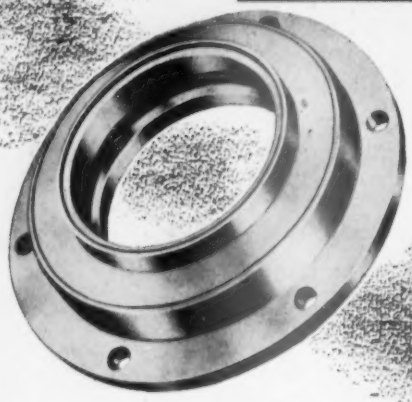

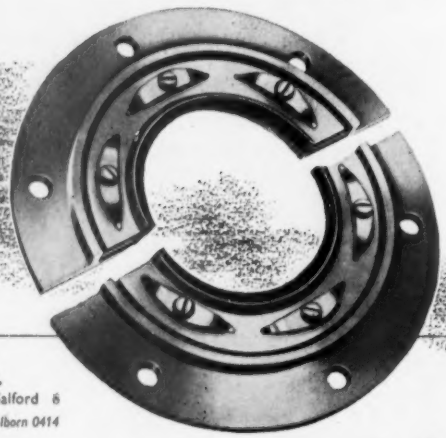

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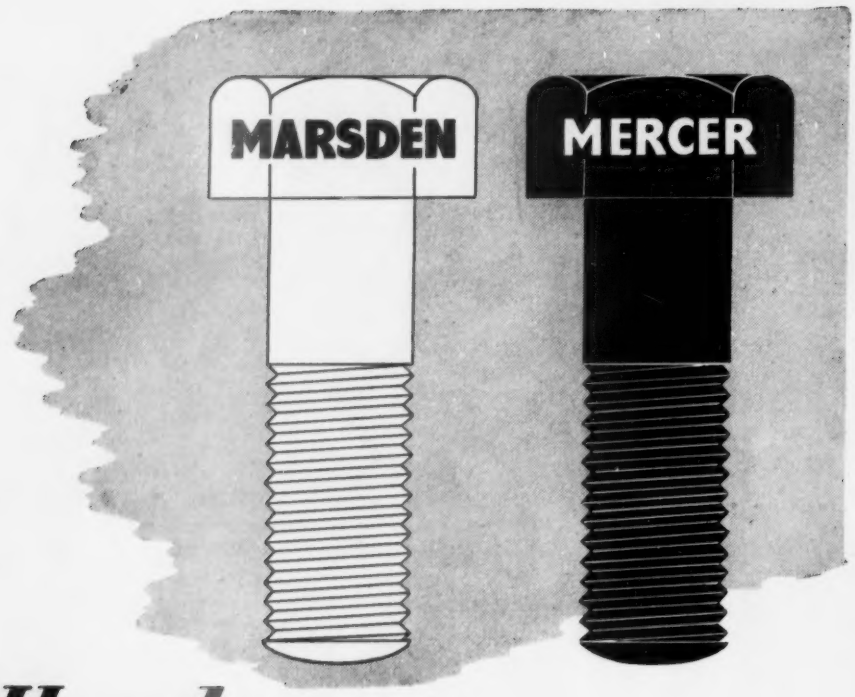

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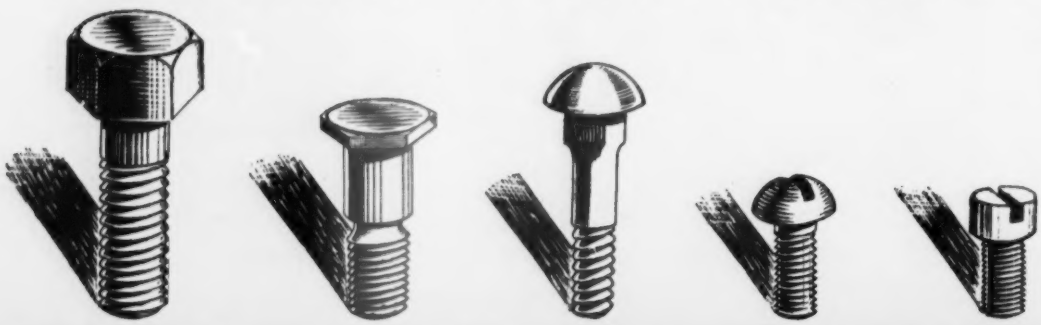

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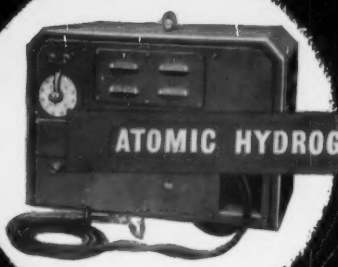

ATOMIC HYDROGEN

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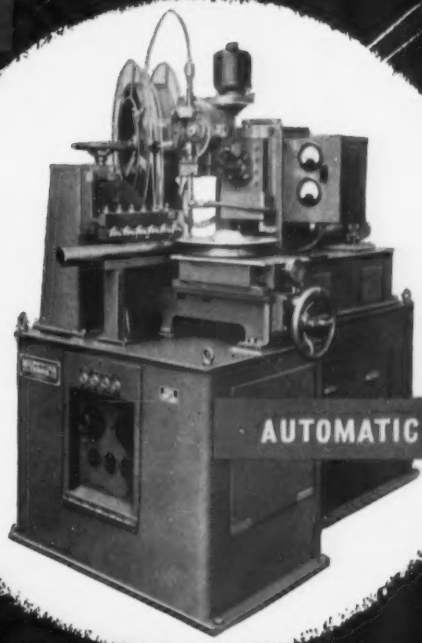
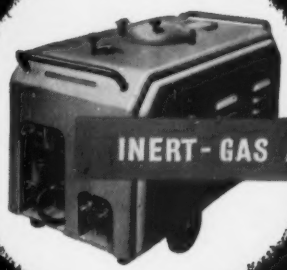


AUTOMATIC ARC



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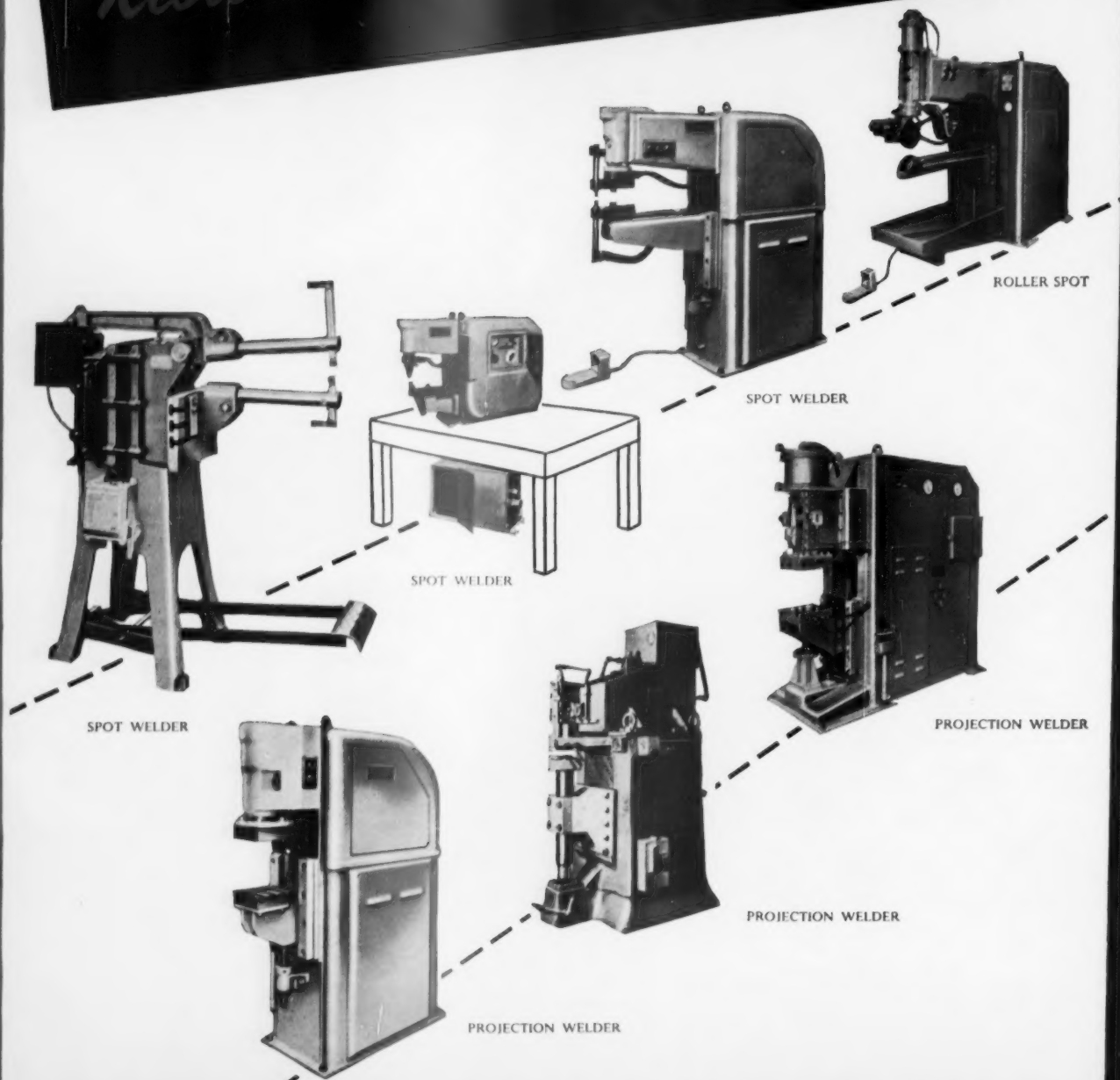

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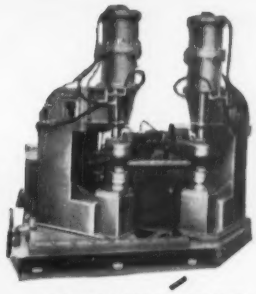

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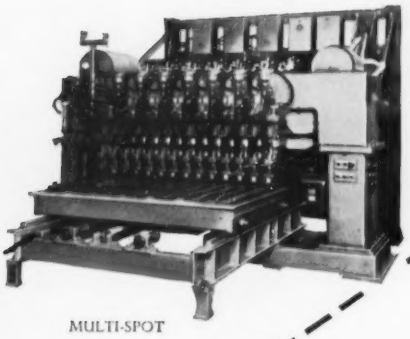

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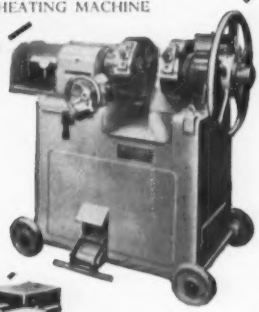
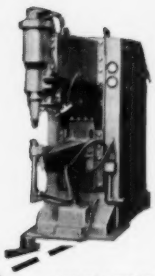
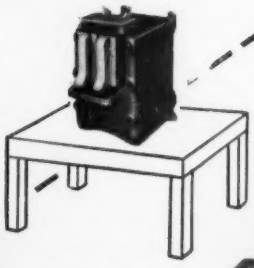


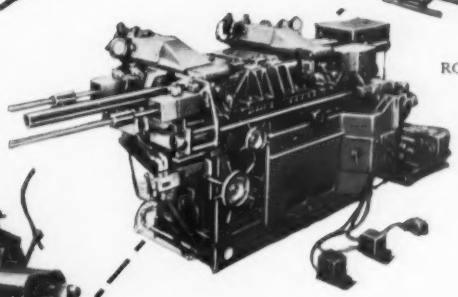
ROPE PARTING MACHINE



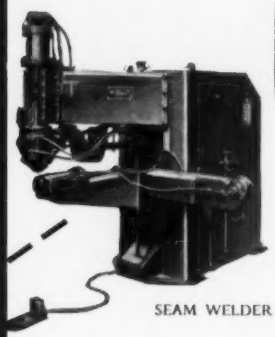
AIRCRAFT SPOT



BRAZING MACHINE



AUTO FLASH BUTT



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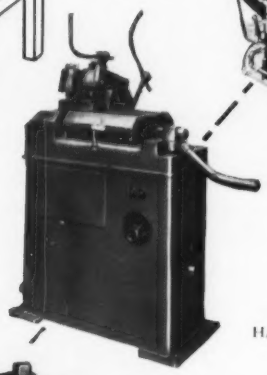
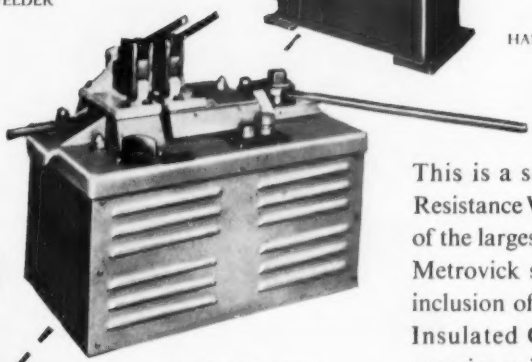
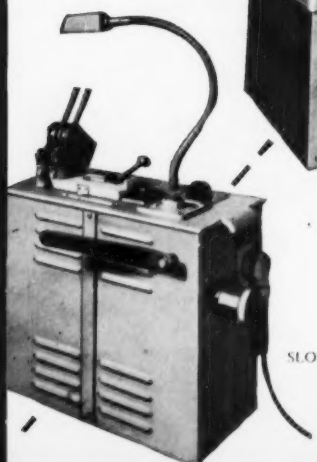


HAND FLASH BUTT



HAND FLASH BUTT



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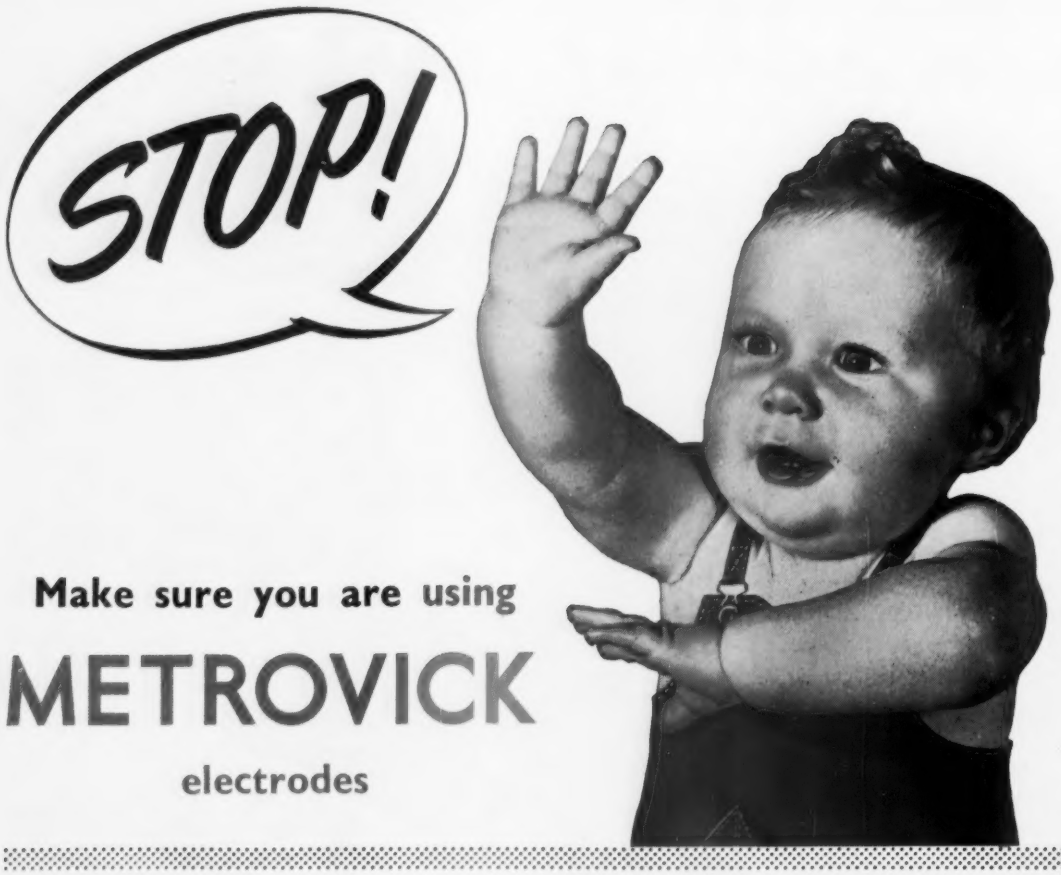

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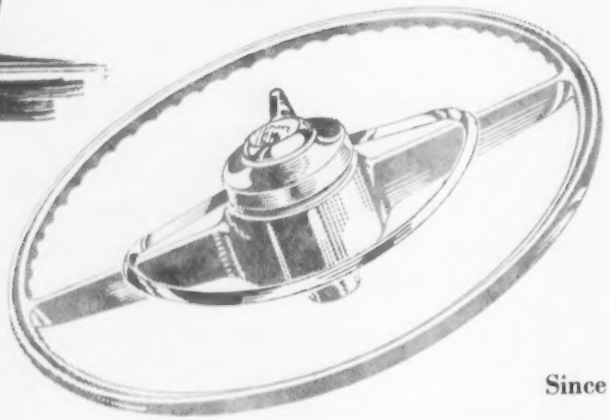
NO ROOM

for complacency here!



Since 1946 we have produced over four million Steering wheels. This gives us no grounds at all for complacency. We are ever striving to improve our technique and our service so as to enhance goodwill and produce always the latest and the best.

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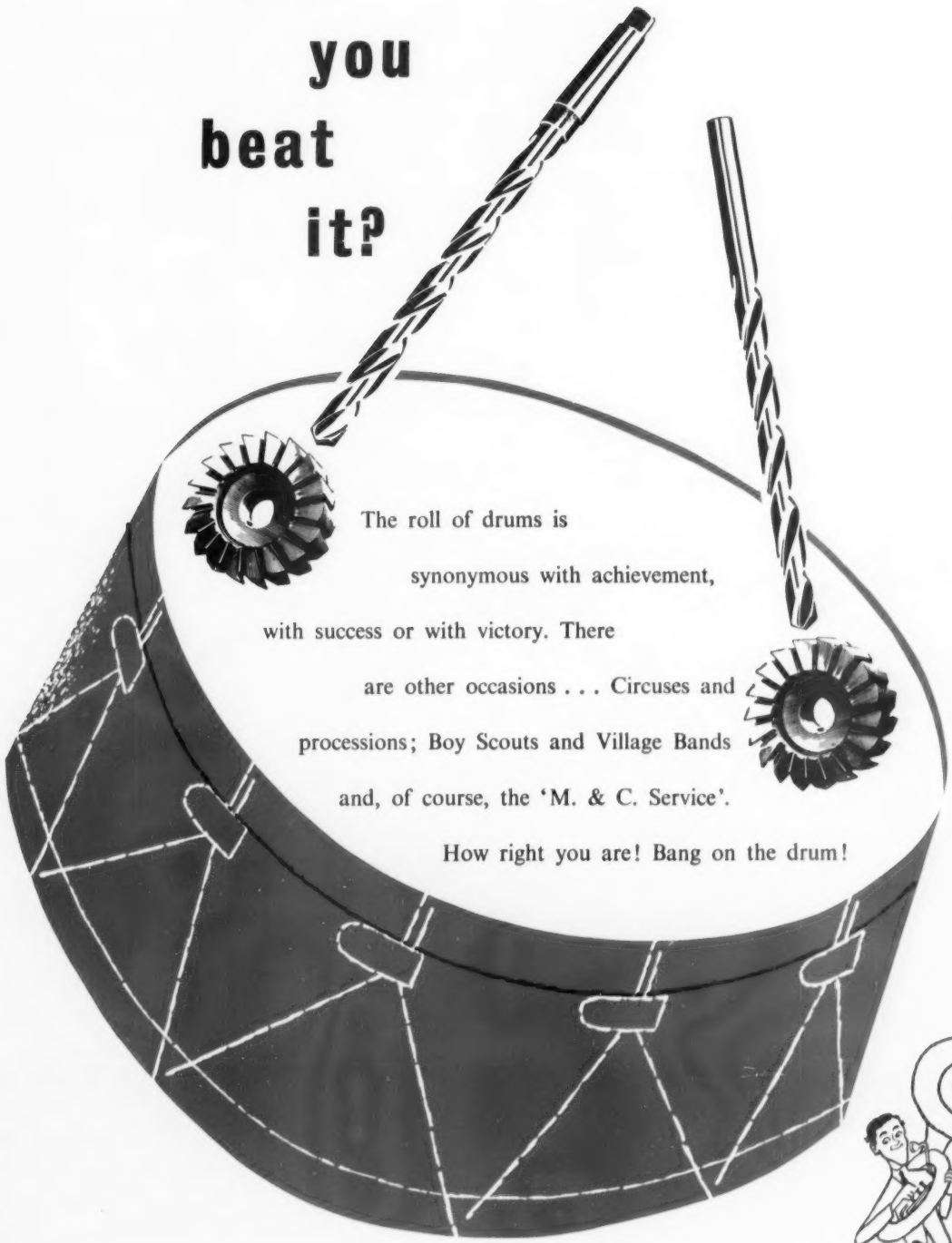

The roll of drums is synonymous with achievement, with success or with victory. There are other occasions . . . Circuses and processions; Boy Scouts and Village Bands and, of course, the 'M. & C. Service'.

How right you are! Bang on the drum!

M&C MONKS & CRANE LTD Britain's Foremost Distributors

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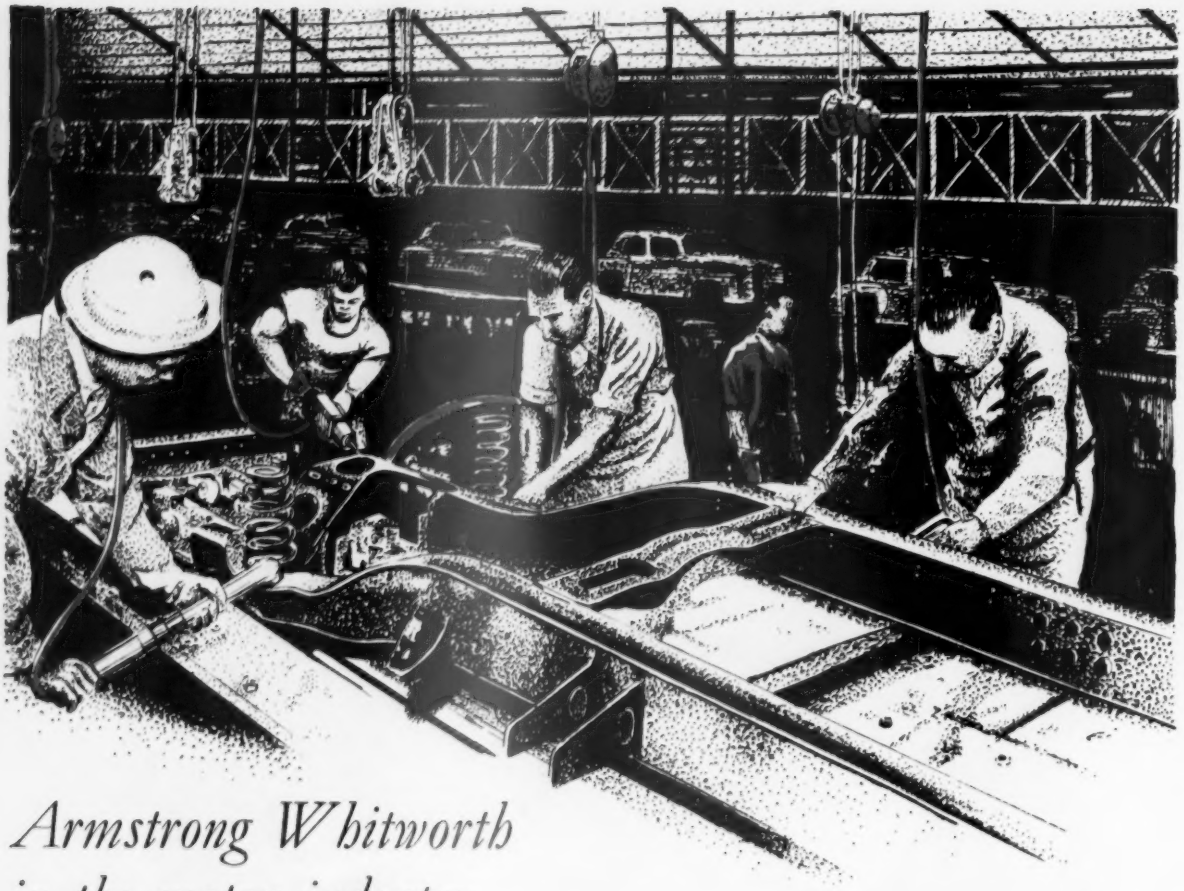

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Speeding production and cutting costs on the assembly lines of many of the world's largest car factories are Armstrong Whitworth Power Tools. Their light weight and perfect balance reduces operator fatigue and steps up efficiency. Their hard hitting power and reliability increases production.
Armstrong Whitworth tools are designed for the manufacturer—with the operator in mind.

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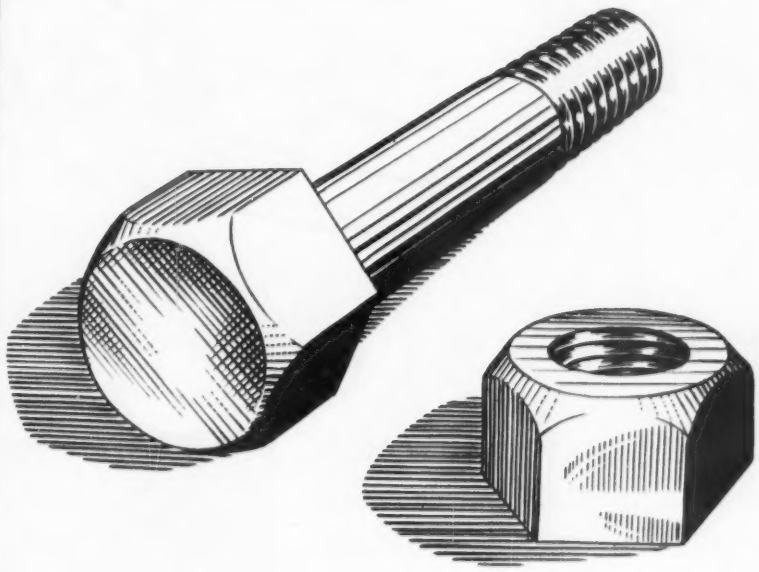

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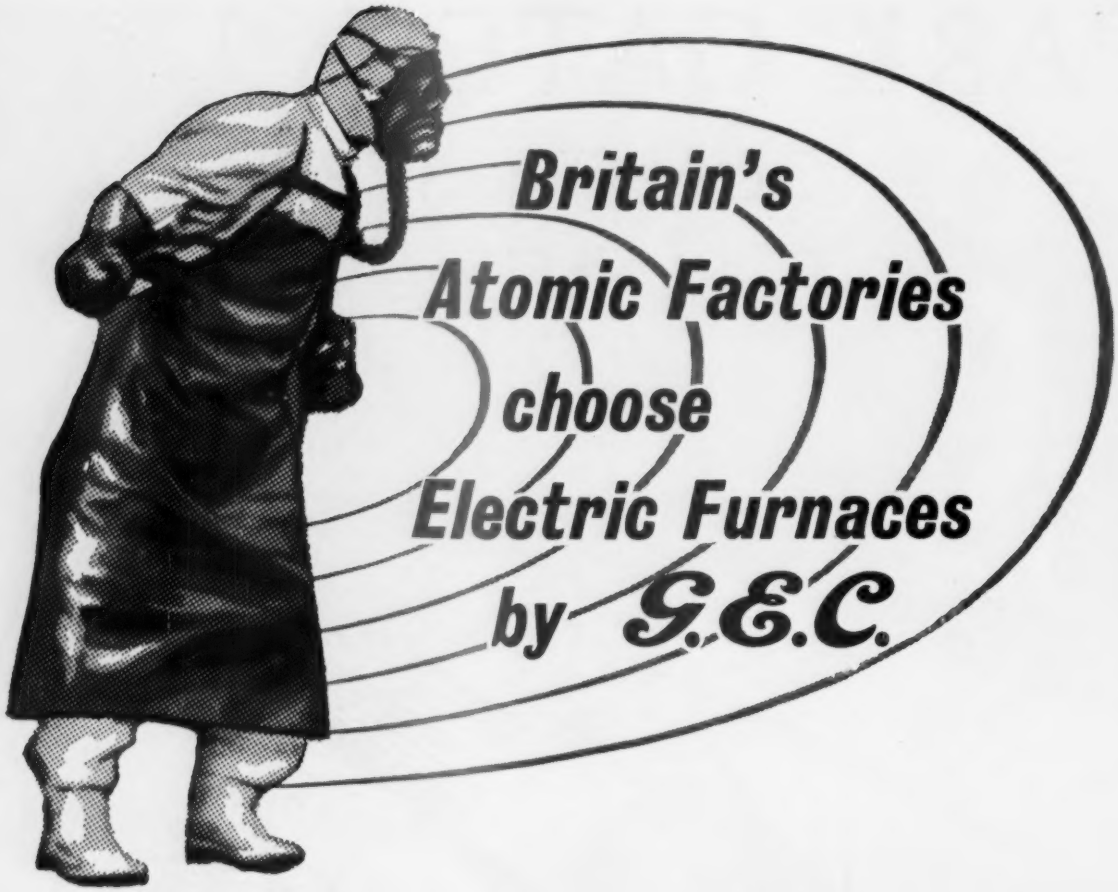
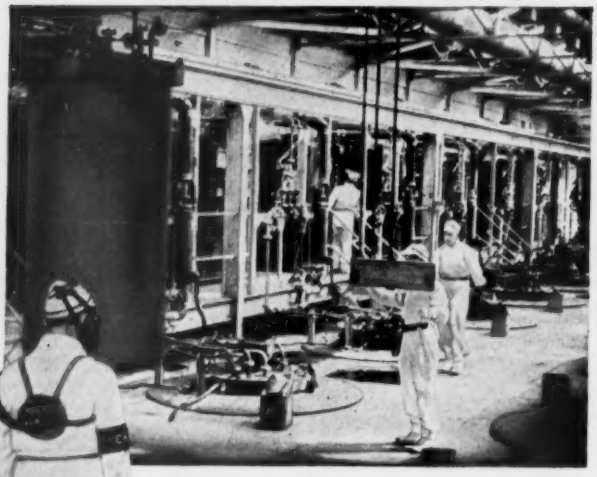


Britain's Atomic Factories choose Electric Furnaces by G.E.C.

Part of the British Atomic Energy furnace installation. The 54 furnaces and 200 furnace pots comprises what is probably the largest single order for furnaces ever placed in any part of the world.



THE VERTICAL CYLINDRICAL FURNACE is a product of the G.E.C. which, since its introduction to Britain more than 20 years ago, has won a high reputation throughout industry for controlled atmosphere processes. Now furnaces of this type are used for processing uranium metal in the British Atomic Energy Plant —a testimonial indeed to G.E.C. dependability and technical skill.

G.E.C. *Electric furnaces for all heat treatment processes*

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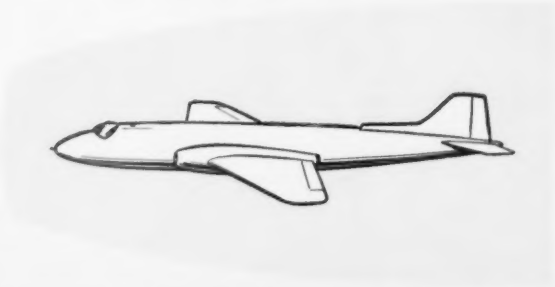
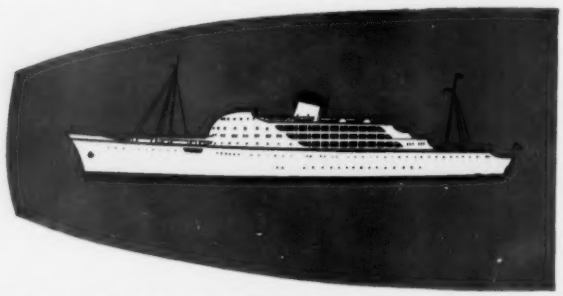
Improved principles of **FUEL BURNING . . .**

the contribution of Lucas research

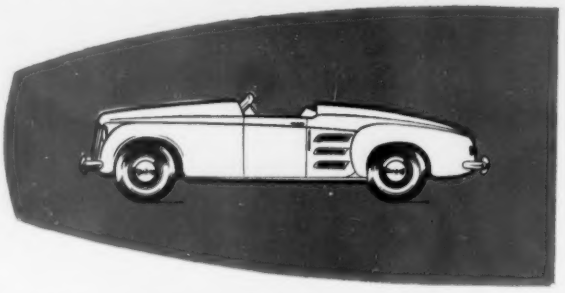


LUCAS holds an unequalled position in the field of fuel-burning. No other company has so much experience or such facilities for the development and production of fuel-burning equipment. By continuous research and the application of improved principles, Lucas has made notable contributions to all industries using motive power . . .

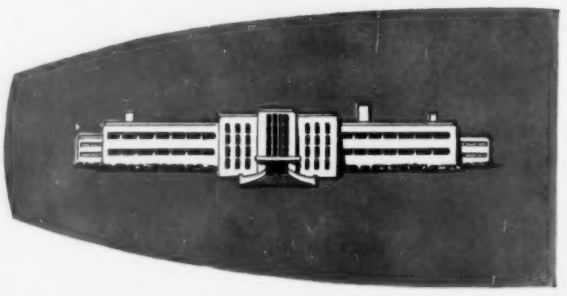
Lucas gas turbine equipment is fitted to the majority of British aircraft, including the Comet, Viscount and Britannia. The Olympus engines of the Canberra which attained the altitude record of 63,668 ft. were also equipped with Lucas components.



- Lucas fuel-burning equipment is on continuous ocean service in a number of modern ships.



- Lucas equipment is installed in the engine of the revolutionary new gas-turbine car—first of its type in the world—made by the Rover Co. Ltd.



- Lucas equipment is incorporated in the gas turbine engines used to power generating plant in large marine and industrial installations.

For all fuel-burning problems, consult the Gas Turbine Equipment Company . . .

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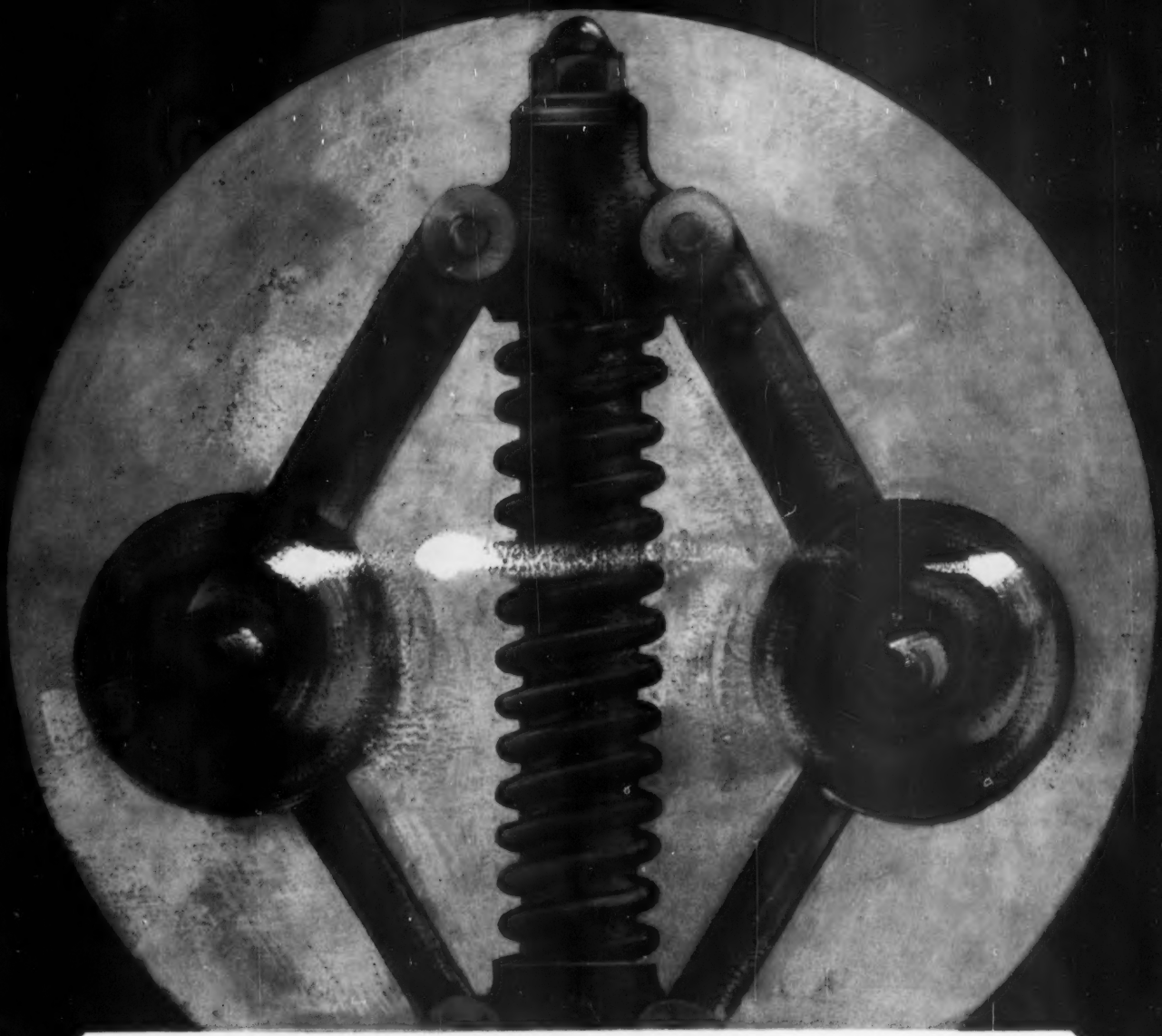
FUEL AND COMBUSTION SYSTEMS FOR GAS TURBINE ENGINES

JOSEPH LUCAS (GAS TURBINE EQUIPMENT) LTD., BIRMINGHAM & BURNLEY.



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The services of our engineers are at your disposal.

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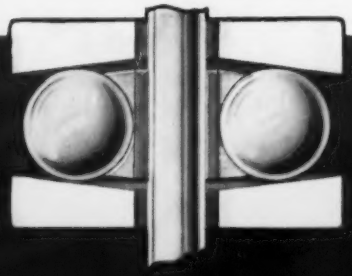

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productivité a doublé et les ouvriers
OUTPUT HAS DOUBLED AND THE HAPPY WORKERS
heureux boivent à la santé de
HAVE BEEN DRINKING THE M.D.'S HEALTH
M. Desoutter toutes les heures du thé
EVERY HOUR IN COLD TEA.
froid. Le vieux sot lui-même est
THE REVEREND GENTLEMAN HIMSELF
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IS UNDER THE TABLE WITH A BOTTLE
de Dubonnet (merci bien!) où il cherche
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INSPIRATION AND THE PEN OF HIS AUNT
pour écrire une autre de
WITH WHICH TO WRITE ANOTHER OF
ses annonces drôles.
HIS SOPPY ADVERTISEMENTS.

(Oh là là! sommes nous tous fous?)
(BLIMEY! HAVE WE ALL GORN NUTS?)

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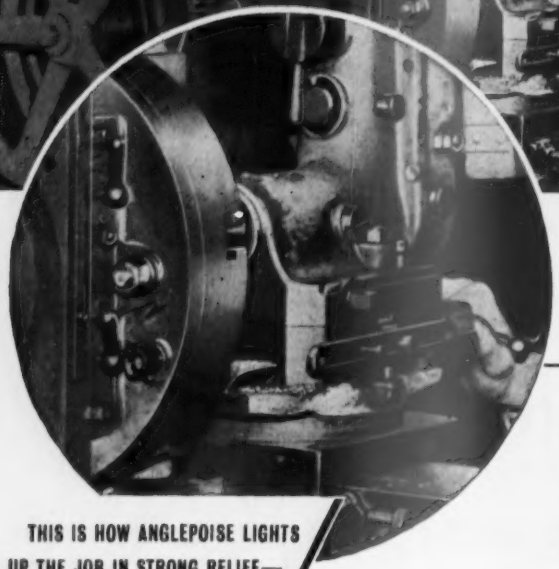

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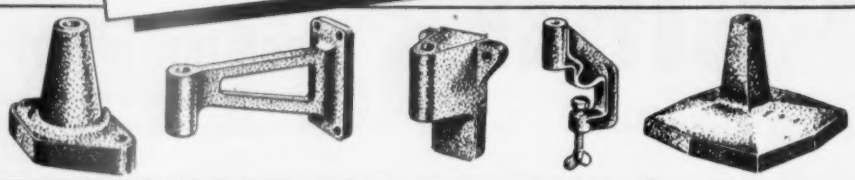

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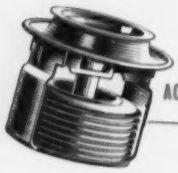
VIRTUALLY EVERY BRITISH CAR
has one or more AC Components designed into it on the drawing-board. We'll gladly help you plan a new design or modify an existing one.



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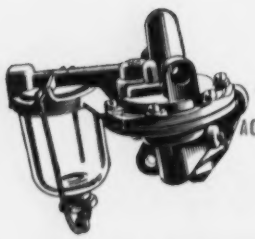

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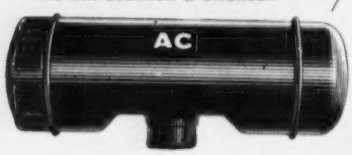

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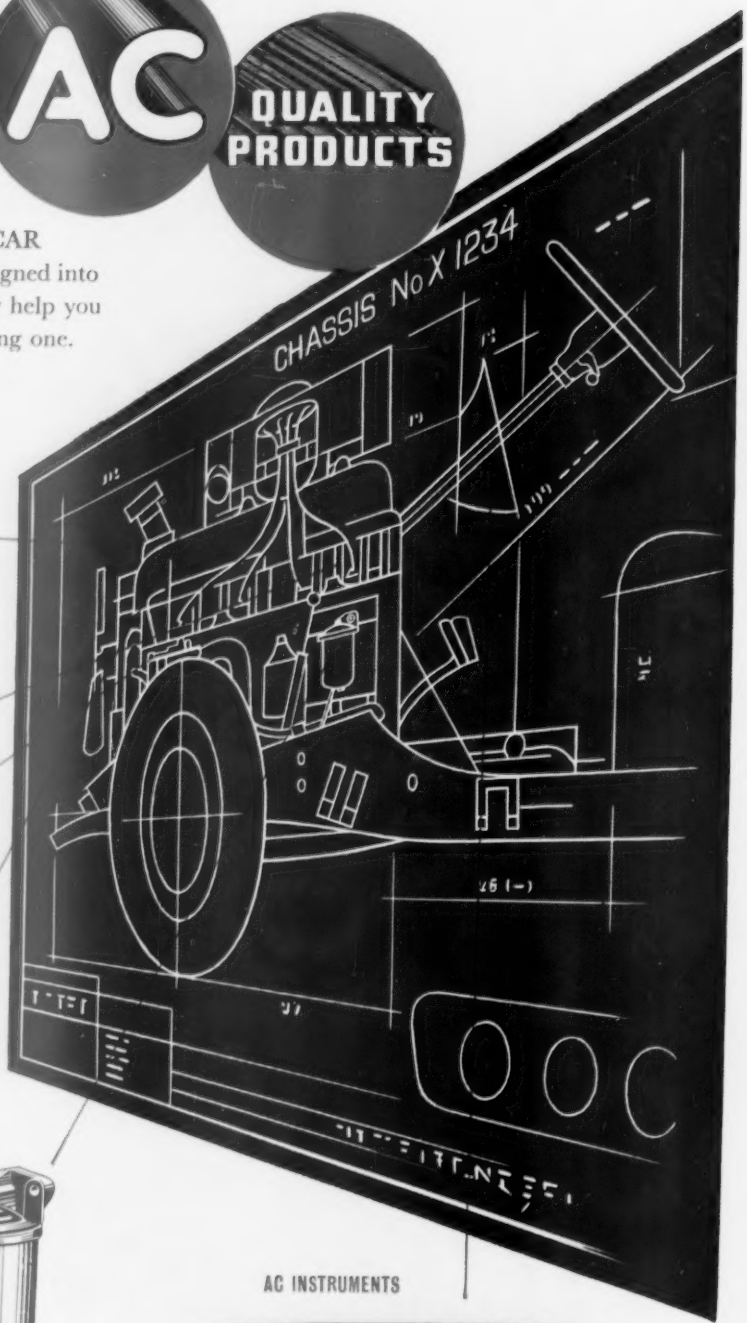
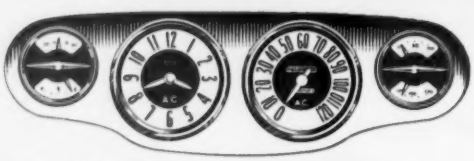


AC INSTRUMENTS



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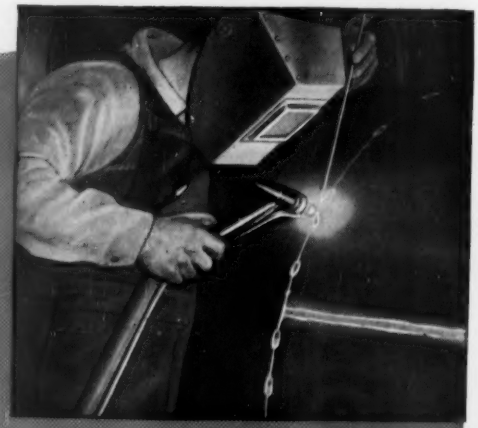
B.O.C Argonarc welds light metals

Welding light metals–aluminium, magnesium and their alloys—is speedy and sure with Argonarc Welding Equipment. Because no flux is used, no corrosion results. The weld is stronger, production time is cut, and electrode wastage is reduced to a minimum. Argonarc Welding is equally well applied to stainless steel sheets. There is little or no distortion, because



NO FLUX-

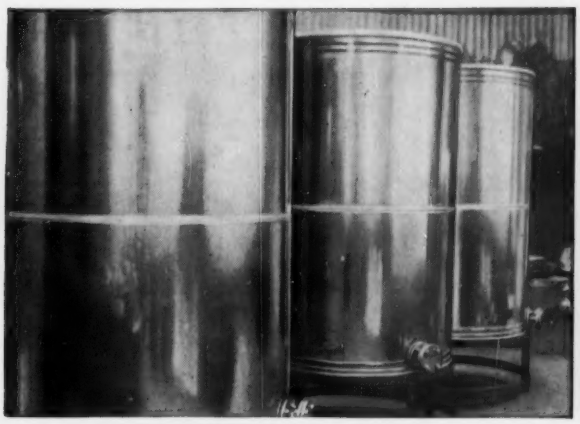
NO CORROSION

the source of heat—the tungsten arc—is small and concentrated.

Some of many highly successful applications are shown here. Note especially the high quality of the weld and a finish so good that there is no need of post-weld cleaning.

We shall be glad to demonstrate Argonarc Equipment. Please get in touch with your local B.O.C Branch

In the construction of light alloy barges, Argonarc welding is used to fabricate many individual parts.



Argonarc Welding of aluminium tanks in the works of Messrs. G. A. Harvey and Co., (London) Ltd. The high quality of the weld eliminates the need for finishing and post-weld cleaning.

Here is the nozzle box assembly for the Rolls-Royce Dart Engine being welded with Argonarc equipment. It gives great strength, and greatly reduces production time. Because no flux is used, no corrosion results.

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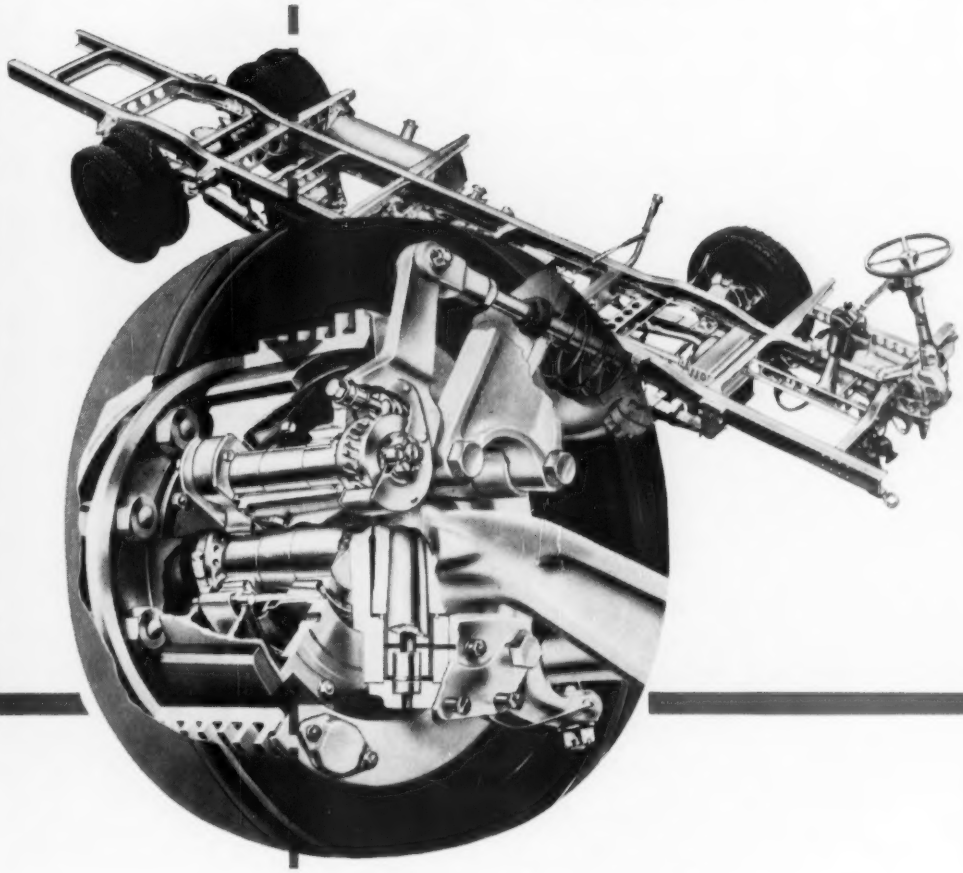

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Measure down to ·059″ diameter

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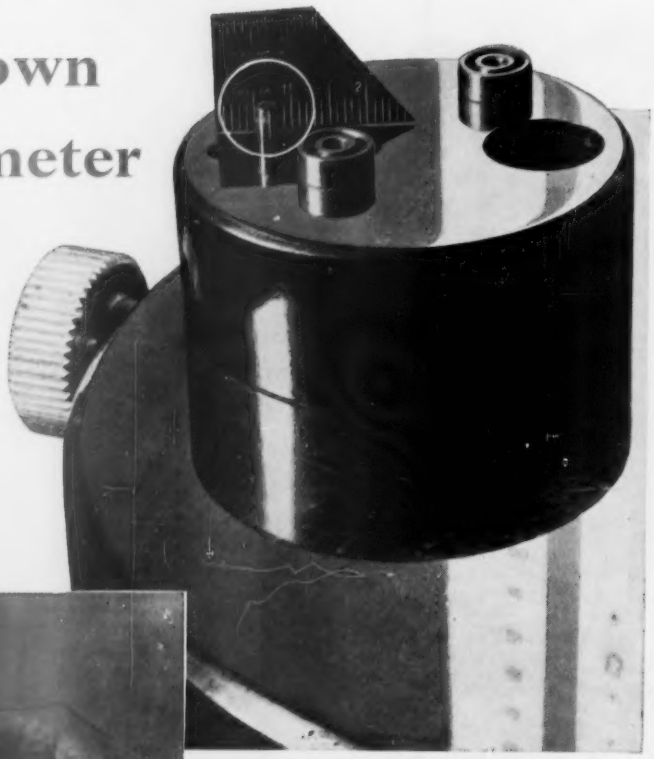

The addition of two new bodies allows this remarkably simple and reliable instrument to cover a range of ·059″ to 6″.

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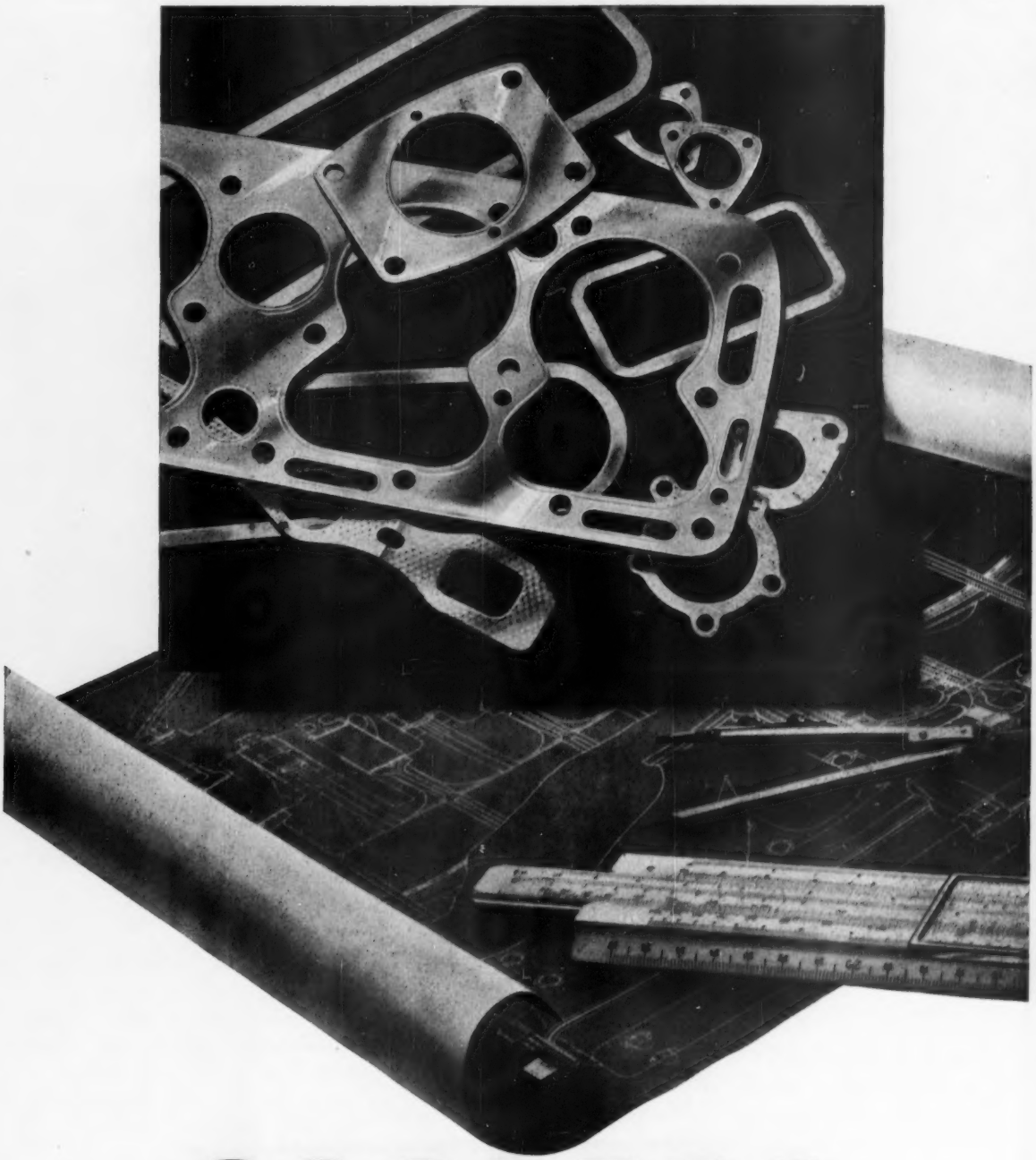
designed to give the utmost efficiency



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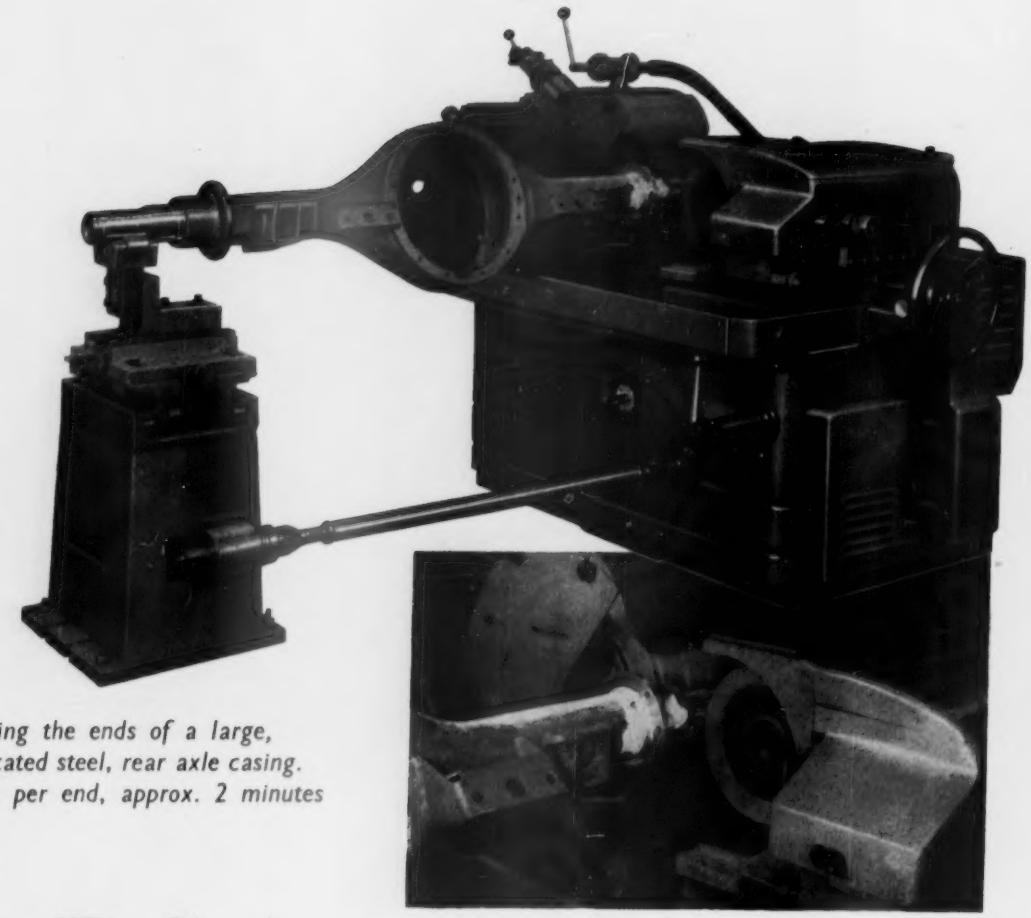

grinding the ends of a large, fabricated steel, rear axle casing. Time, per end, approx. 2 minutes

on a B.S.A. No. 8 Centreless Grinding Machine

	TWO SIZES: No. 4	No. 8
Diameter of work ground	$\frac{1}{16}$" to 3"	$\frac{1}{8}$" to 6$\frac{1}{2}$"
Capacity for bar grinding	$\frac{1}{16}$" to $\frac{1}{2}$" up to 10ft. long	$\frac{1}{8}$" to 2" up to 14ft. long
Speed of grinding wheel	1,270 rpm.	1,180 rpm
Number of control wheel speeds	4	12
Drive	10hp. 1455rpm.	20hp. 1460rpm.
Floor space occupied	56" × 57"	66" × 74"

The machine is equipped with a mechanical in-feed attachment and a specially designed outboard support which compensates for the slight angling of the component axis which occurs as stock is removed. A universal drive, linked to the in-feed mechanism and coupled to a lead-screw inside the support, causes the outer end of the component to traverse forward. The movement is equivalent to half the stock removal, so that the component axis is constantly parallel to the control wheel. Both wheels are form trued.

FOR RAPID AND EFFICIENT FINISHING OF TAPER, SHOULDERED, SPECIAL FORM, MULTI DIAMETER AND PLAIN CYLINDRICAL

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Elongation:	18%	Elongation:	6%
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We offer your designers the full collaboration of our engineers.

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Problems of wear, corrosion or heat resistance can be solved by the use of either "PARSONS" Manganese Bronze, "IMMADIUM" High Tensile Bronze or "CROTORITE" Aluminium Bronze.

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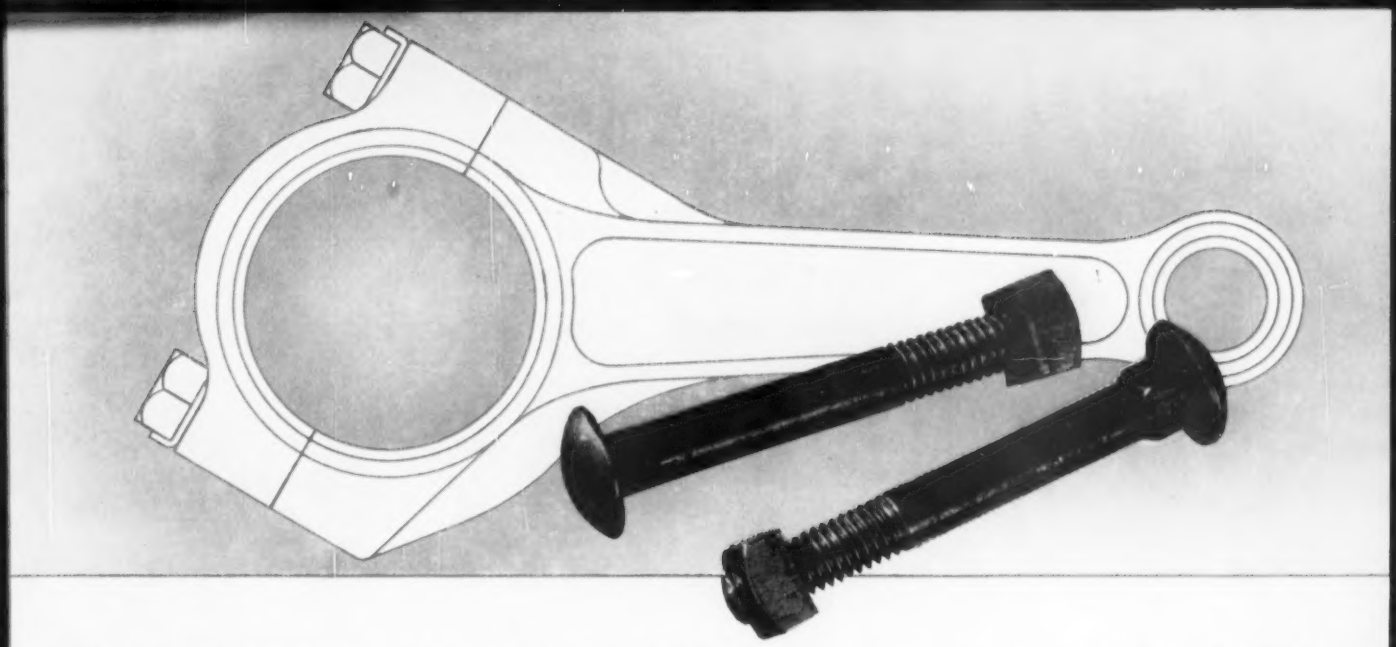
G.4



TWO WAYS OF INCREASING LOAD CAPACITY

OR

"You wouldn't put coach bolts in your big ends!"

ONE WAY of increasing bearing capacity, of course, is to use a bigger bearing. The other way is to add more refinement. It doesn't look noticeably different on the drawing or on the assembly bench, for it consists of putting a higher quality into the same size of bearing.

BUT THE DIFFERENCE IS OUTSTANDING

F.B.C. bearings evolved for high-duty aircraft applications have raised the bearing performance to an almost unbelievable figure, by their high-precision, extra quality and detail development in relation to ball location and contact.

In the light of present day knowledge, therefore, to use an 'ordinary' catalogued ball-bearing for a border-line high-duty job is as near to sabotage as putting M.S. bolts into a racing-car big-end.

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FISCHER BEARINGS CO. LTD., WOLVERHAMPTON

FISCHER BEARINGS COMPANY LTD., and TIMKEN-FISCHER STOCKISTS LTD., BIRMINGHAM
are both subsidiaries of BRITISH TIMKEN LTD.

COVENTRY MOTOR FITTINGS

CMF

Radiator Production Specialists

50 years experience of cooling design problems and quantity radiator production. Our Design Dept. is able at any time to put forward a suitable type of radiator or allied equipment for your special requirements.

COVENTRY MOTOR FITTINGS CO. LTD.
COVENTRY Tel. 5144/5.6.

Incorporating the C.M.F. FLAT TUBE BLOCK

Cogent

HERBERT

INSPECTION

INSPECTION is an essential part of production, the inspection department needs time-saving appliances just as much as the machine shop. For years we have specialised in the supply of modern optical measuring instruments by the use of which inspection can be speeded up and made more accurate.

HILGER UNIVERSAL PROJECTOR

Particulars of these instruments will be found in our catalogue MODERN INSPECTION EQUIPMENT, a copy of which will be sent on request.

THE HILGER UNIVERSAL PROJECTOR shown here, combines the functions of a projector and a precision measuring machine reading to ·0001". It can be supplied for surface projection to deal with obscured forms. The precision protractor, graduated 90° on either side of zero reads directly to 1 minute.

All interested in inspection are invited to visit our Measuring Room at Coventry where the application of modern inspection equipment can be studied.

Full particulars available from:—

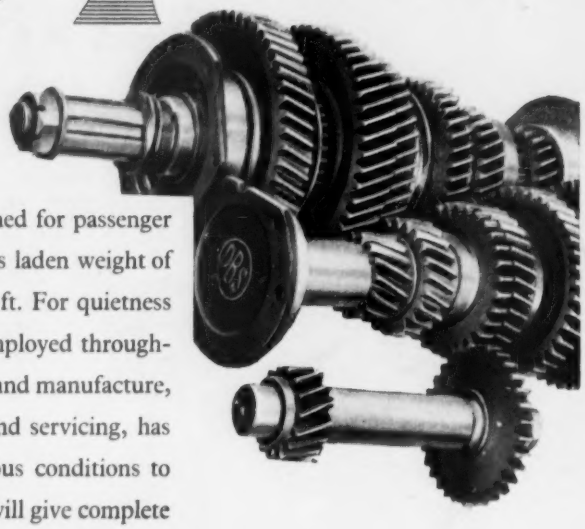
Measuring Room, Head Works

'Phone: 88781—Ext. 139

SOLE AGENTS:—

ALFRED HERBERT LTD · COVENTRY

GEARBOX 557 FIVE SPEED



The David Brown model 557 gearbox is designed for passenger vehicles or for commercial vehicles up to a gross laden weight of 22 tons with maximum engine torque of 350 lb. ft. For quietness and ease of operation constant mesh gears are employed throughout, including reverse. Every feature of design and manufacture, affecting chassis layout, operation, mounting and servicing, has been carefully studied and tested under rigorous conditions to provide a simple, rigid and balanced unit that will give complete dependability in service. Our illustrated specification gladly sent on request.

WITH DIRECT OR OVERSPEED TOP GEAR

STANDARD GEAR RATIOS GIVE THESE ALTERNATIVES

Fifth	Fourth	Third	Second	First	Reverse
1/1	1.565/1	2.74/1	4.68/1	7.92/1	7.92/1
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THE
DAVID BROWN
CORPORATION (SALES) LIMITED
AUTOMOBILE GEARBOX DIVISION
PARK WORKS HUDDERSFIELD

FOR QUICK DELIVERY

4 BRANCHES *at your service*

STEEL SHEETS

Cold-reduced : Hot-Rolled
Galvanized or black,
also mild steel plates
up to and including ¼in.
SHEARED TO YOUR SIZES

May we send you our stock list?
If you would like to have it regularly,
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SPENCER

H. F. SPENCER & CO. LTD., WOLVERHAMPTON

There's more life in BRIGHTRAY

COATED EXHAUST VALVES

During the war BAC Brightray* was applied to most aero-engine exhaust valves to counteract the corrosive action of the lead content in very high octane fuel. Since then this coating technique has proved successful in increasing valve life in diesel engines, especially those designed for heavy fuels. Besides affording protection against corrosion the coating withstands severe overheating in the engine without burning. A Brightray coating can be applied at very little cost, either during manufacture or for reclaiming burnt-out valves. (The process simply involves the deposition of BAC Brightray to the seat, rim and edge of the crown of the prepared valve using an oxy-acetylene flame. The valve is then machined and ground to finished dimensions.)

We shall be happy to send you a list of manufacturers who supply Brightray-coated valves and of firms who undertake reclamation. Firms who wish to carry out Brightray coating of valves on their own account should send for the booklet, "Brightray-coated Exhaust Valves".

**BAC Brightray is an 80/20 nickel chromium alloy supplied as welding wire. (The name Brightray is a registered Trade Mark).*

RECLAIMING A BURNT VALVE

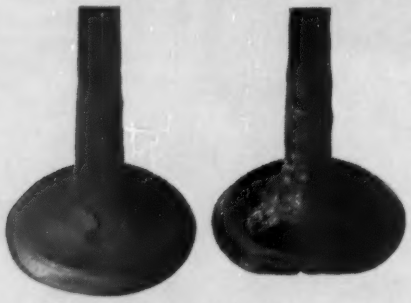


Fig. 1. Valves as taken from engine.

Fig. 2. Cleaned and machined ready for application of BAC Brightray coating.

Fig. 3. After application of coating.

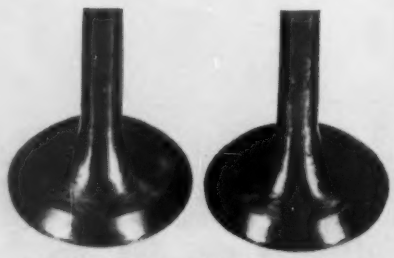


Fig. 4. Valves machined, ground and ready for replacement.

HENRY WIGGIN & COMPANY LIMITED · WIGGIN ST. · BIRMINGHAM 16

COMPO - the *complete* bearings

The selection of bearings is a highly important factor in the production of any piece of machinery. Efficient, constant lubrication, coupled with a precision fit, is the first requirement of a bearing and reliable delivery at economical cost is the second. From the extensive range of Compo bearings you can be assured of the efficient accuracy of the one and the reliability of the other. The Compo range of over two thousand sizes means that there is almost certainly a "ready-made" bearing to meet your specification both as to size and the mechanical requirements of speed and load.

Remember, our Technical Department has specialised knowledge, plus experience, which may help you overcome your bearing problems. Please let them try.

★ **BOUND BROOK BEARINGS LTD.** are also specialists in the fabrication of sintered components by the powder metallurgy process.

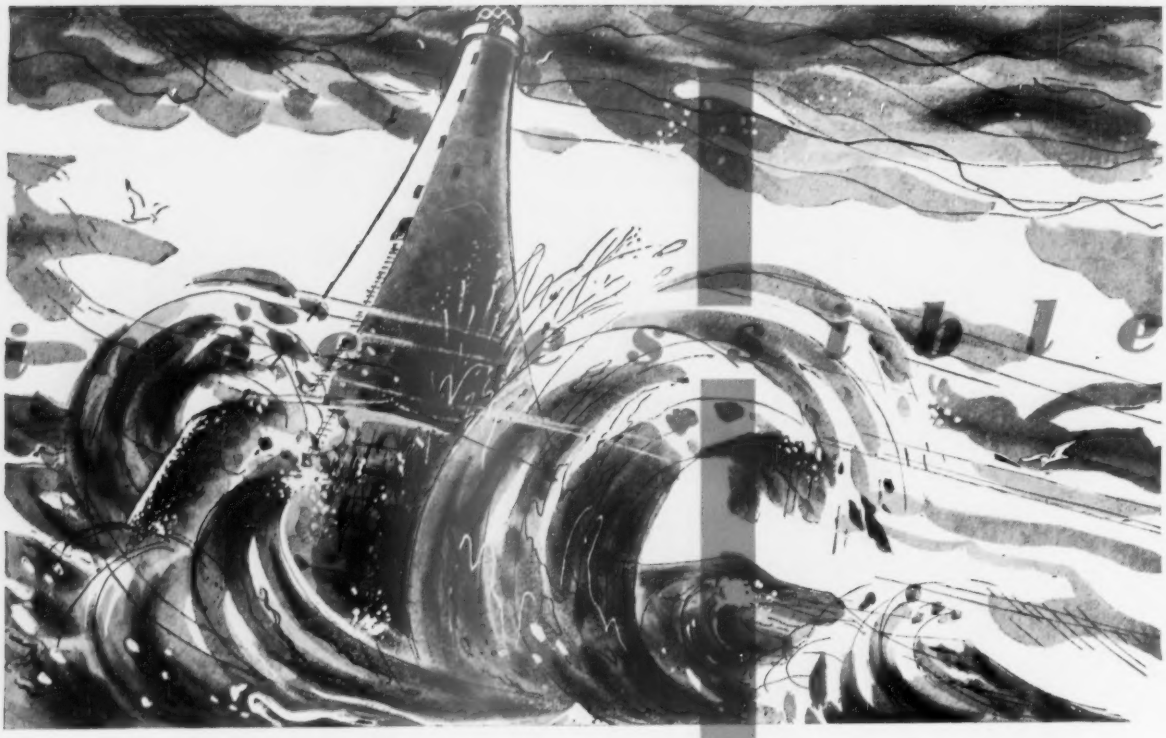
COMPO

OIL RETAINING

BEARINGS

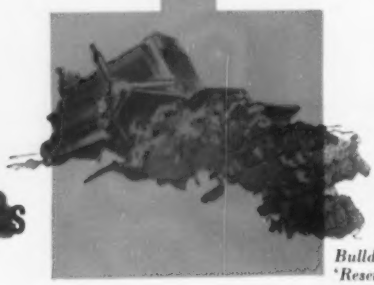
BOUND BROOK BEARINGS LTD., TRENT VALLEY TRADING ESTATE, LICHFIELD, STAFFS

Telephone: Lichfield 2027-2028 *(A Birfield Company)* *Telegrams: Boundless, Lichfield*



The Lighthouse, *proud guide over the storm ravaged ocean and warning sentinel against the lethal power of rock and current, lights up the problems of inaccessibility. These problems are more easily solved in industry and the home, in equipment where maintenance for lubrication is difficult or undesirable, by the use of "Reservoil" sintered-metal oil-retaining bearings. With these, oil is fed by capillary action to the bearing surfaces, providing trouble-free lubrication automatically.*

Reservoil
SINTERED METAL
OIL RETAINING BEARINGS



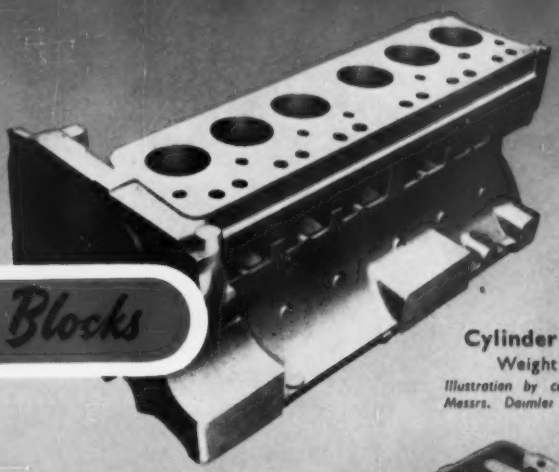
Bulldozers are an instance where 'Reservoil' bearings are used to advantage. These bearings are supplied in shapes and sizes for every normal medium duty, but attention is drawn to the range of plain cylindrical bearings to B.S.I. Standard dimensions. Write for Catalogue S D 40.

THE MORGAN CRUCIBLE COMPANY LTD., BATTERSEA CHURCH ROAD, LONDON, S.W.11. *BATTERSEA 8822*

SM. 120

Cast Iron

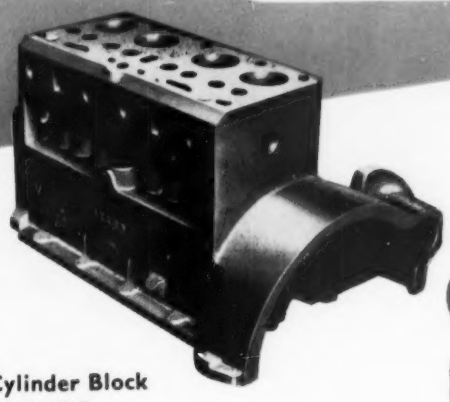
Cylinder Blocks



Cylinder Block
Weight 633 lbs.
Illustration by courtesy of Messrs. Daimler Co. Ltd.

Cylinder Heads

Cylinder Head
Weight 143 lbs.
Illustration by courtesy of Messrs. John I. Thornycroft & Co. Ltd.



Cylinder Block
Weight 90 lbs.
Illustration by courtesy of Messrs. Morris Motors Ltd.

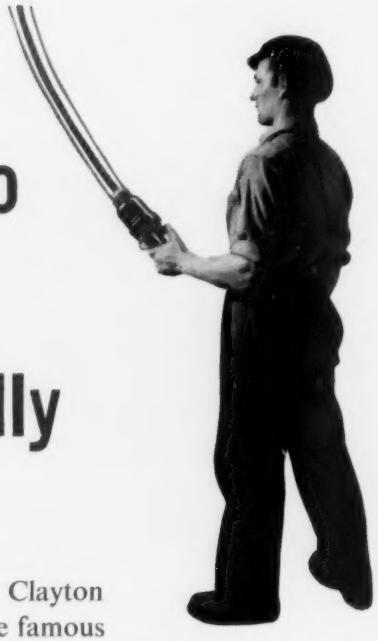
STERLING

METALS LTD.
Coventry

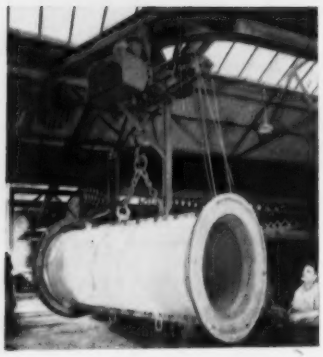
TELEPHONE: COVENTRY 89031 (6 LINES) TELEGRAMS: STERMET PHONE COVENTRY

*Also Manufacturers of Sand and Gravity Die Castings in Aluminium and "**ELEKTRON**" Magnesium Alloys*

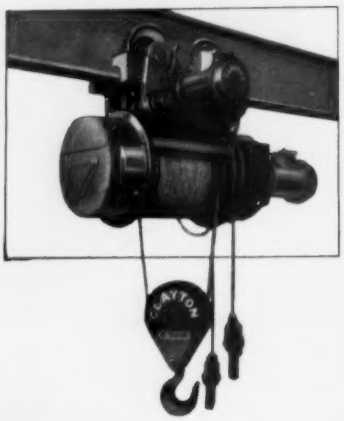
The man who couldn't wobble a jelly



. . . is the man in control of a Clayton Hoist fitted with micro-speed—the famous combination that gives rock steady, dead slow speeds on alternating current. Five-ton moulds and cores can be manoeuvred into position with ease and safety, by (if necessary) unskilled workmen. In machine assembly, heavy parts can be placed with absolute precision. This, in fact, is the only go-slow movement in industry that speeds production.



Big firms that have streamlined their factories with Clayton Hoists include Rolls-Royce, English Electric, Ford Motor Co., Leyland Motors, Lever Bros., Shell Oil—but naturally the only firm you really care about is your own and we suggest that you'll be micro-creeping-slow if you don't send for our latest catalogues now !



CLAYTON

electric hoists with micro-speed units

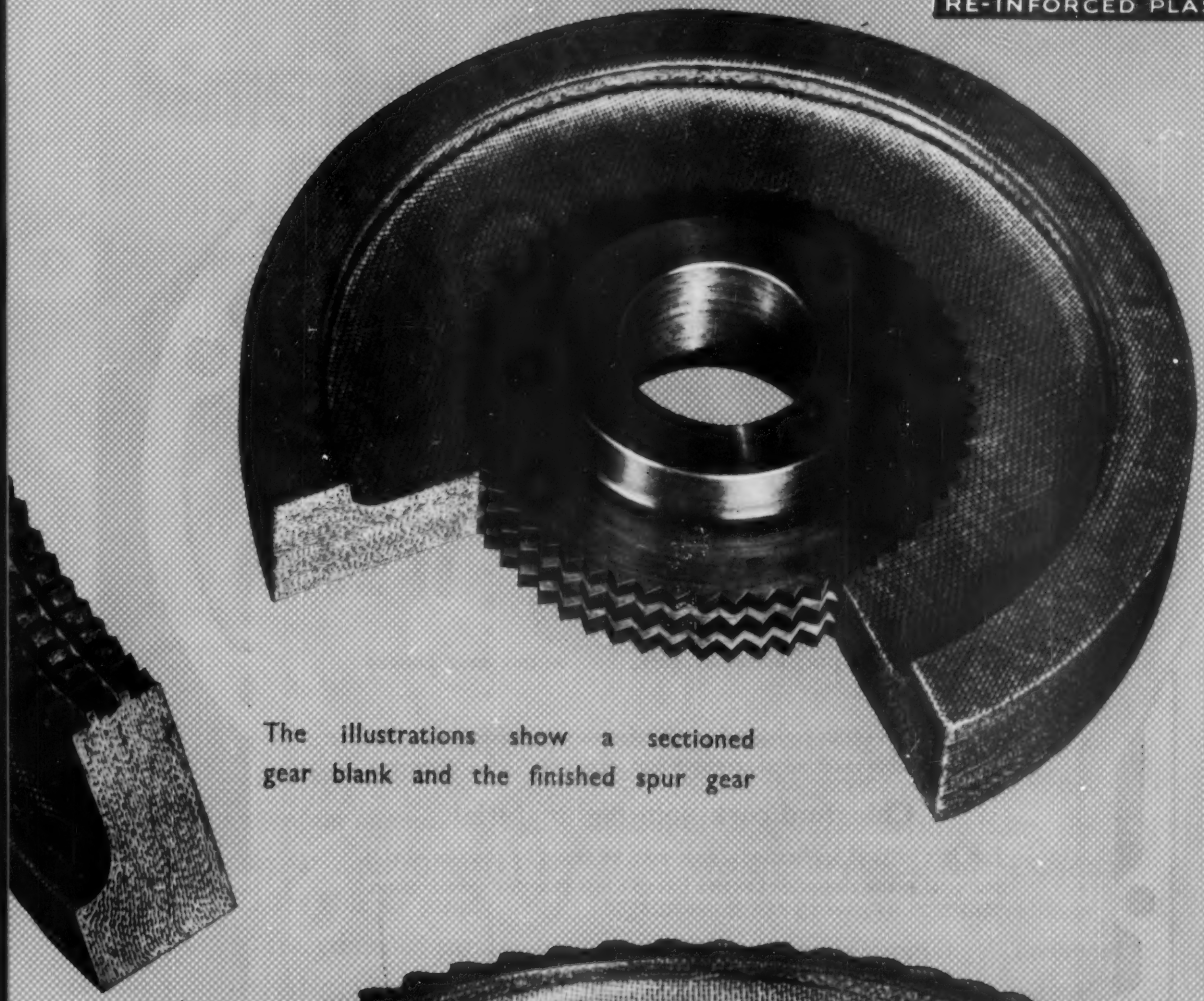
put things precisely in their places

THE CLAYTON CRANE & HOIST CO. LTD., DEPT. 17, IRWELL CHAMBERS EAST, UNION STREET, LIVERPOOL, 2
TELEPHONE: CENTRAL 1141 (4 *LINES*) *TELEGRAMS: CLAYMAG LIVERPOOL*

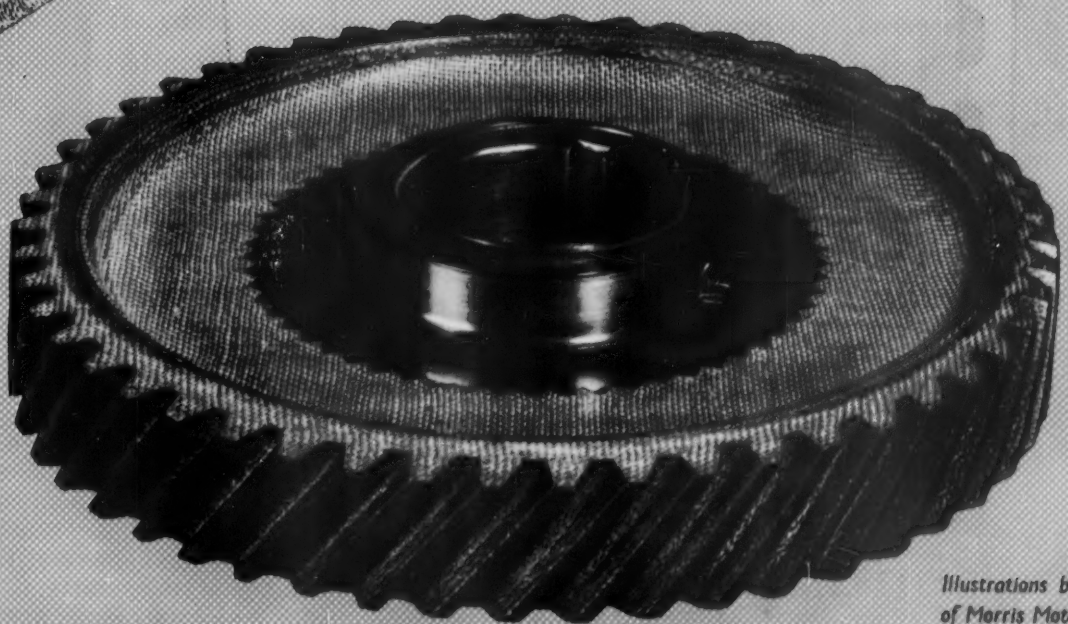
RE-INFORCED MOULDINGS

better in TEXOLEX

RE-INFORCED PLASTICS

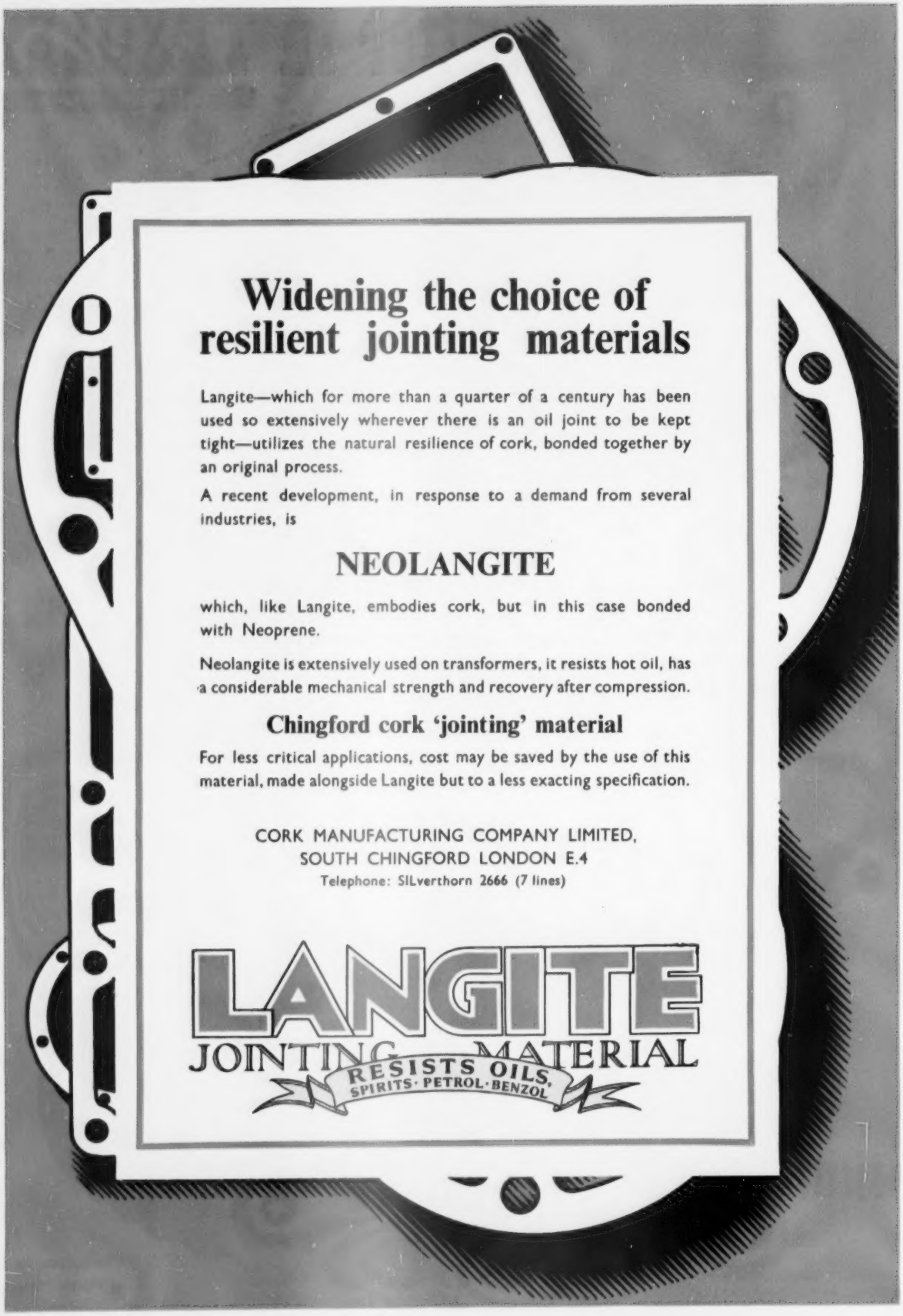


The illustrations show a sectioned gear blank and the finished spur gear



Illustrations by courtesy of Morris Motors Limited

THE BUSHING CO. LTD., HEBBURN-ON-TYNE



Widening the choice of resilient jointing materials

Langite—which for more than a quarter of a century has been used so extensively wherever there is an oil joint to be kept tight—utilizes the natural resilience of cork, bonded together by an original process.

A recent development, in response to a demand from several industries, is

NEOLANGITE

which, like Langite, embodies cork, but in this case bonded with Neoprene.

Neolangite is extensively used on transformers, it resists hot oil, has a considerable mechanical strength and recovery after compression.

Chingford cork 'jointing' material

For less critical applications, cost may be saved by the use of this material, made alongside Langite but to a less exacting specification.

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Telephone: SILverthorn 2666 (7 lines)

LANGITE
JOINTING MATERIAL
RESISTS OILS, SPIRITS · PETROL · BENZOL

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These five words are familiar to every buyer of machinery who scans the "Plant for Sale" columns of the national and technical press. They serve as a reminder that Thos. W. Ward are able to supply new, secondhand and reconditioned machinery of every conceivable kind, and their enormous range usually makes further searching unnecessary. But this is only a small part of the service which the Ward Group of Companies offers to industry. In the 75 years since its foundation, the Ward organisation has grown to embrace almost every facet of industrial activity. Today, Ward products and services are part of industrial life everywhere in the world.

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ALBION WORKS · SHEFFIELD

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Unique

"Newallastic" bolts and studs have qualities which are absolutely unique. They have been tested by every known device, and have been proved to be stronger and more resistant to fatigue than bolts or studs made by the usual method.

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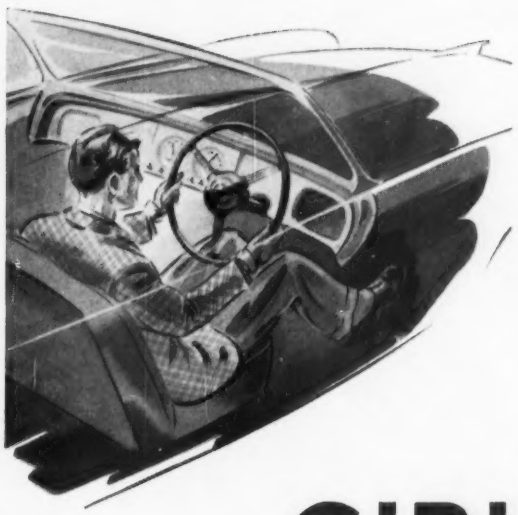
MOTOR SHOW · EARLS COURT 1954

The advent of

POWER ASSISTED STEERING



—another lead by GIRLING in the drive for safer motoring

As a direct contribution towards ease of handling and the elimination of fatigue when driving the heavier cars, as well as goods and passenger vehicles of all kinds, Girling Limited have developed a hydraulically operated device which gives power assistance to the effort derived from manual turning of the steering wheel.

Even on the heaviest vehicles the device gives a lightness yet sureness of steering "feel" that has to be experienced to be appreciated, and the design is such that the power assistance can never in any circumstances get out of hand. It must always remain instantly and completely subordinate to the dictates of the steering wheel and to the hand of the driver.

GIRLING

THE BEST BRAKES IN THE WORLD

again Way Out Ahead

GIRLING LIMITED
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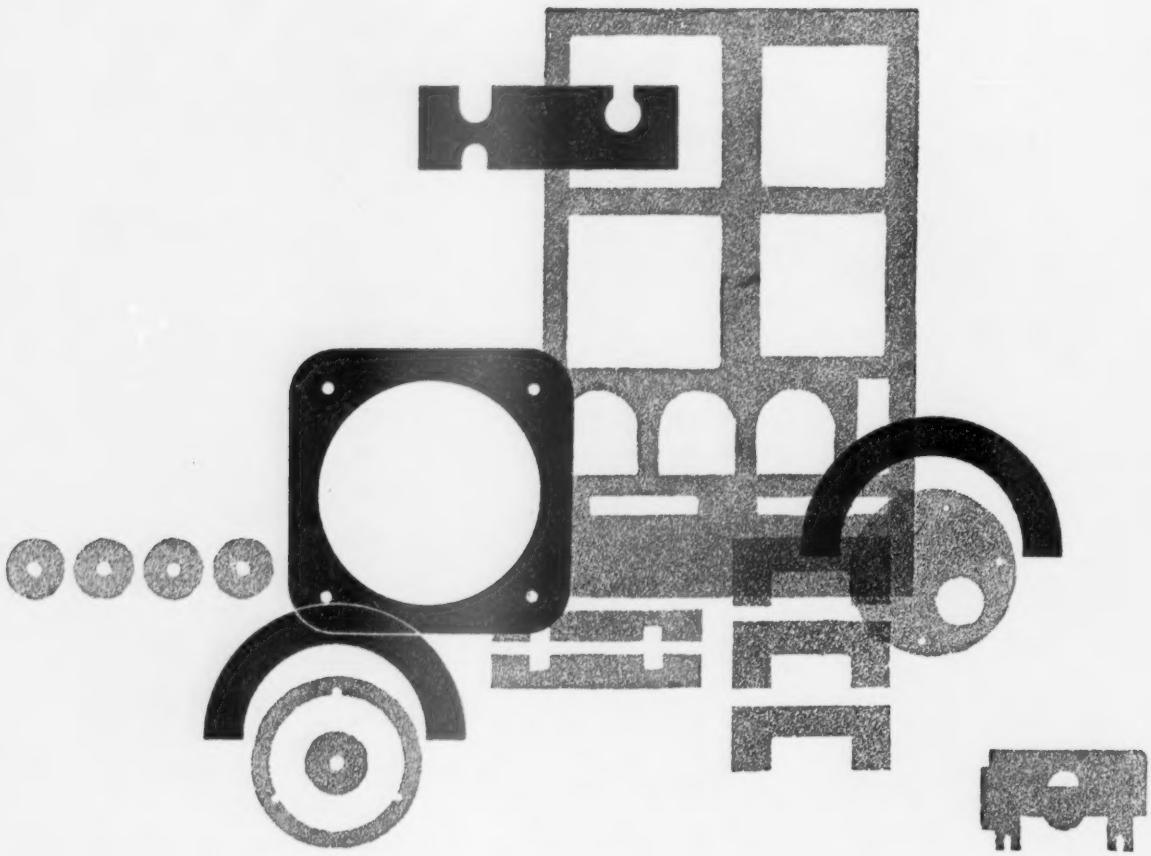

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Name your needs in felt and we'll give you just what you want — the right weight, the right texture, the right grade. Quick delivery (either in the piece or cut and punched to your requirements) is part of the Meadowfelt service. Meadowfelt prices are right, too. *Send for samples and full details.* We'll be glad to help with advice on any problem concerning felt.

when you need felt... **say Meadowfelt**

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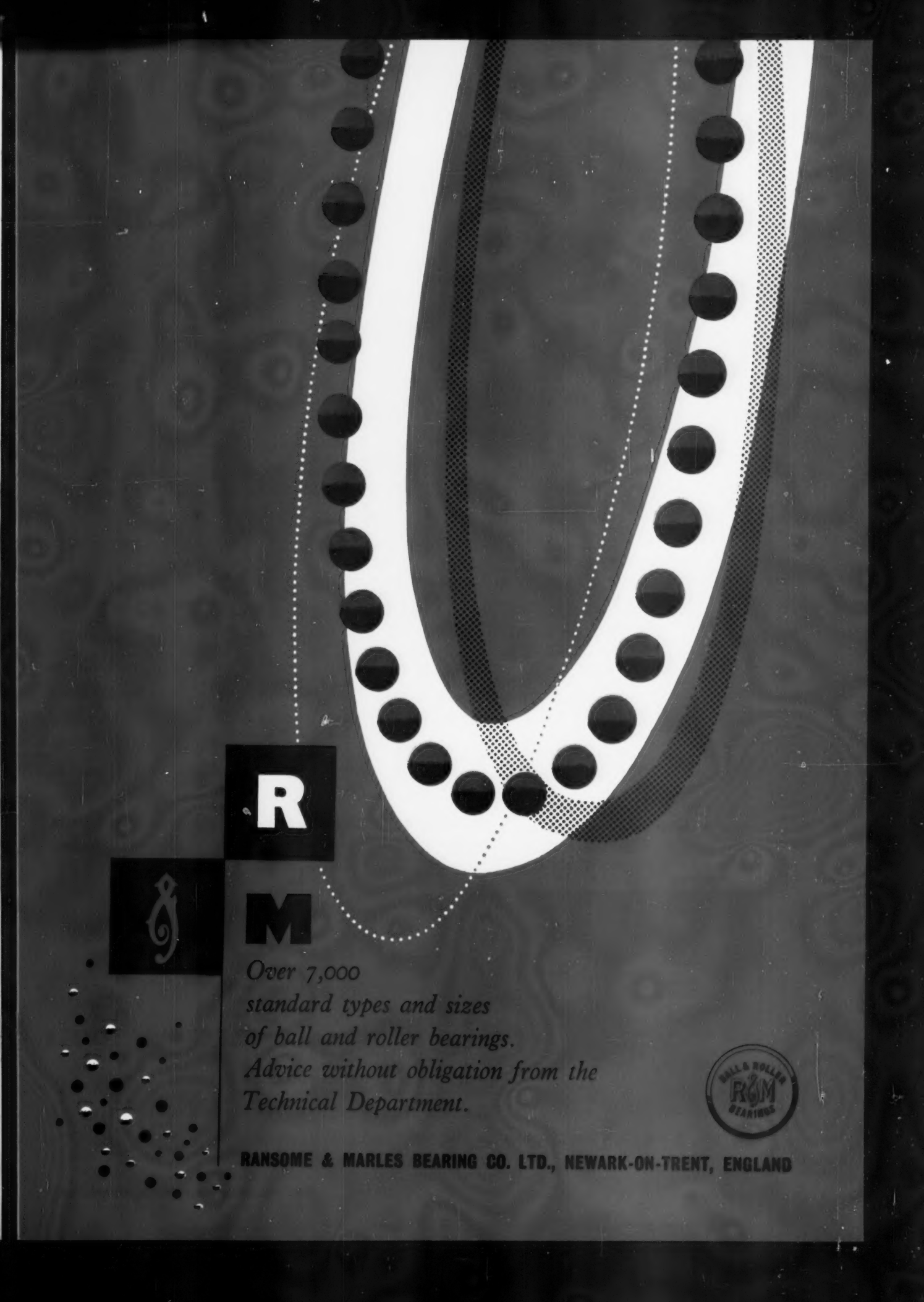
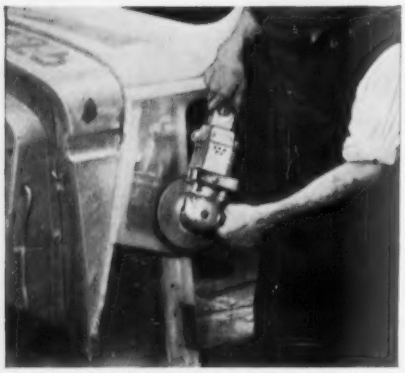


Over 7,000
standard types and sizes
of ball and roller bearings.
Advice without obligation from the
Technical Department.

BALL & ROLLER R&M BEARINGS

RANSOME & MARLES BEARING CO. LTD., NEWARK-ON-TRENT, ENGLAND

The 7 inch Heavy Duty Sander



Built for long life and hard work, *the B & D Sander rubs down old paint, leaving the surface satin-smooth.*

Fast, versatile, adaptable *B & D Sanders cut time and costs on both production and maintenance work.*

Built for many jobs

Here's a tool that's really versatile . . . it's built to sand, surface, de-rust . . . smooth down rough welds, rub down paint on wings or body panels prior to re-spraying . . . ideal for all body construction and general maintenance work. You must have many uses for this tough, dependable Sander, made by the world's largest manufacturers of portable electric tools for all industries. Other B & D tools include, Saws, Drills, Hammers, Screwdrivers, Bench & Portable Grinders.

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Low first cost
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This new filter has been expressly designed to remove the extremely minute dust particles, carried in suspension in fuel oil, which are responsible for most of the wear in pumps and injectors. Extensive field tests under arduous conditions at home and overseas have proved it possible to obtain six times the injection equipment life compared with that using older methods of filtration. The overhaul and maintenance costs of fuel injection equipment are thus greatly reduced and engines are kept longer in service.

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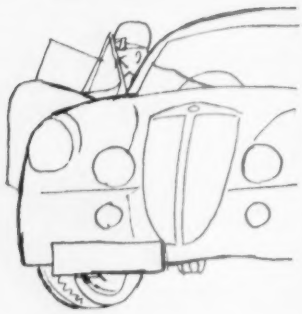
Ferodo make doubly



Heavy transport lorries, light delivery vans, racing and family cars—all kinds of vehicles, all over the Ferodo Anti-Fade Brake Linings . . . quite a respo So Ferodo make doubly sure of quality . . . doubly sure of safety . . . by methodical testing and precision manufacture.

TESTING takes place throughout the production of Ferodo Anti-FadeBrake Linings, from investigation of basic materials to inspection of finished products. The laboratory, the uniquely equipped Test House, the powerful cars of the Ferodo Test Fleet, all are constantly at work, making the efficiency and safety of Ferodo Linings a calculated certainty.

FERODO FACILITIES FOR RESEARCH AND TESTING ARE FREELY AVAILABLE TO THE MOTOR INDUSTRY AT ALL TIMES

sure

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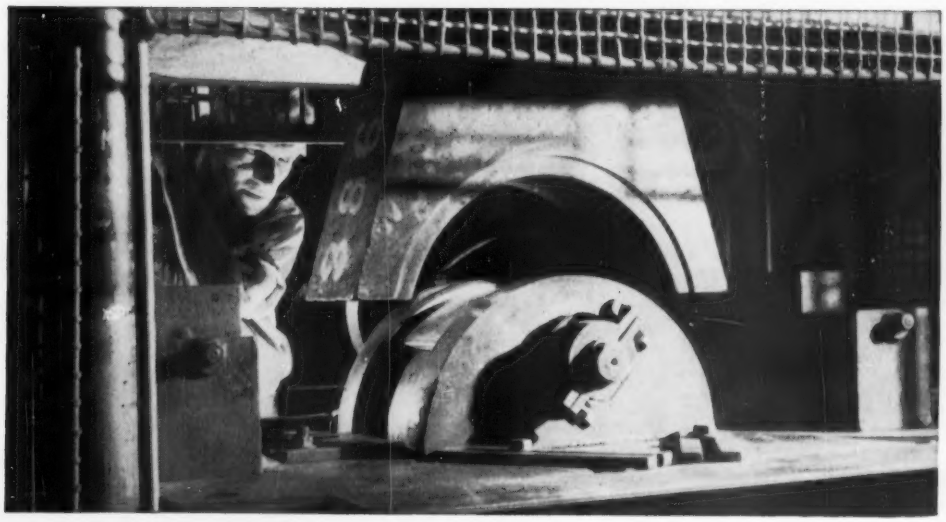
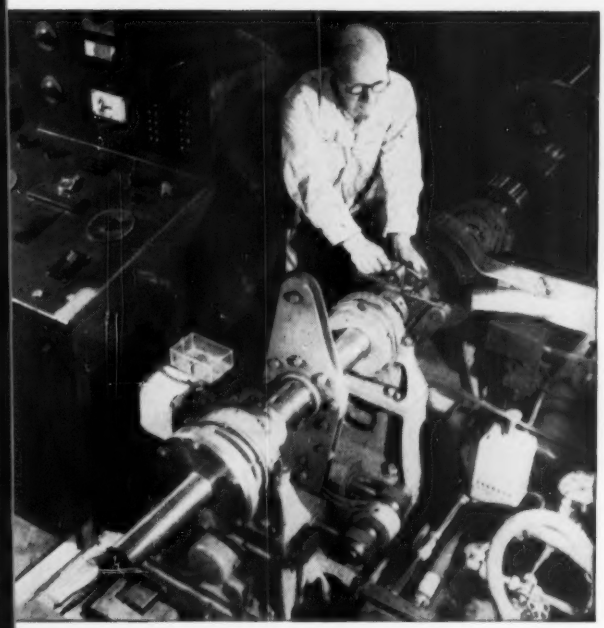


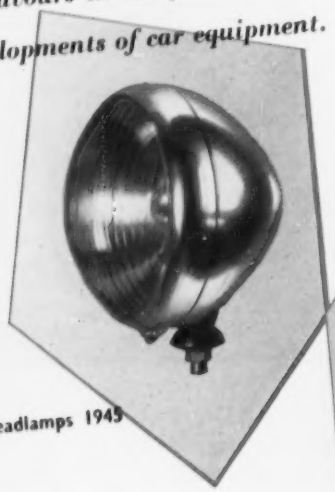


In the MANUFACTURE of Ferodo Linings, the emphasis is on precision. Whether it's a hydraulic press forming liners to their finished radius, or a giant multiple drill, every machine is itself the result of research and experience. This fact, combined with strict examination at every production stage, ensures that on any make of car in the world, the correct Ferodo Lining will always fit perfectly.

FERODO ANTI-FADE Brake Linings Clutch Facings

FERODO LIMITED • CHAPEL-EN-LE-FRITH *A Member of the Turner & Newall Organisation*

Lucas Research with its great resources of highly specialized knowledge and experience forms a complete liaison with modern manufacturing techniques to build for the present and plan for the future. The result of these combined endeavours in the field of electrical engineering is reflected in the post-war developments of car equipment.



Headlamps 1945

Headlamps 1954

The modern headlamp incorporates a Lucas Light Unit, a combined front lens and reflector assembly giving permanent protection to the all-important reflecting surface.

This highly reflective surface, achieved by an aluminising process, is unaffected by climatic conditions. A pre-focus double-filament bulb is employed, giving correctly focused beams at all times.

Complete control of light distribution is achieved by small flutes and prisms of pre-determined optical characteristics incorporated in the "block-pattern" lens moulding resulting in higher standards of illumination.

Consequently, double dipping can be employed with no increase in dazzle over the former "dip and switch" system, and solenoid dipping devices are eliminated.

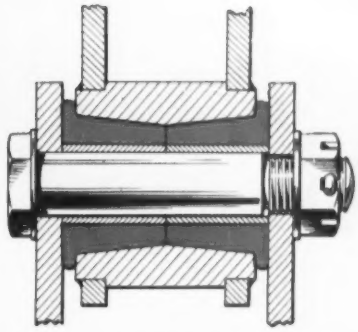
Specially designed racing headlamps have been developed which enable speeds of 100-150 m.p.h. to be obtained at night with safety. These have been used with success in such events as the "Le Mans 24 Hours," etc.

LUCAS

JOSEPH LUCAS LTD . BIRMINGHAM . ENGLAND

Silentbloc

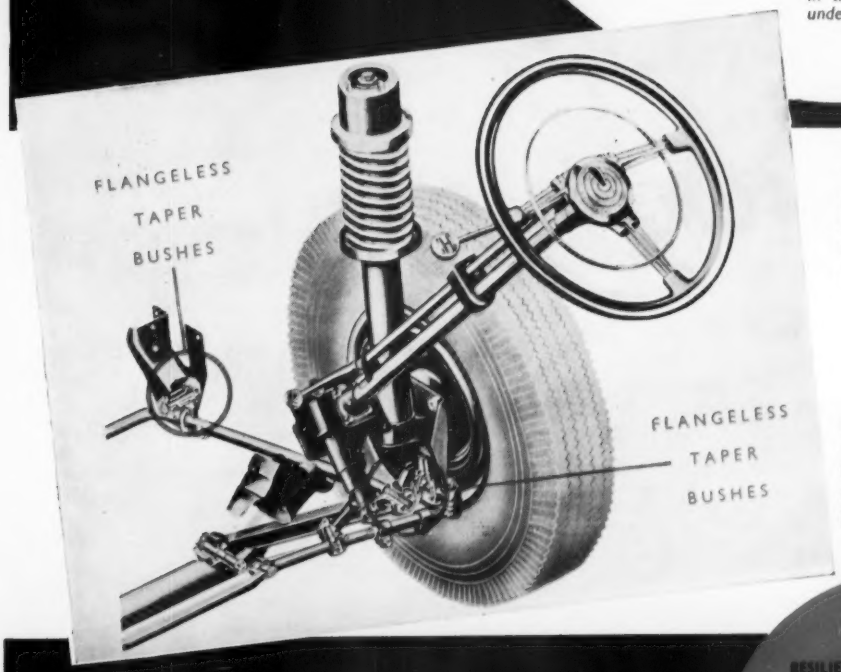
FLANGELESS TAPER BUSHES for I.F.S systems



Scientific Development Cuts Costs

Constructed on the Silentbloc principle with a self-forming flange for extra-snug fitting and less wear these bushes ensure maximum efficiency at lowest cost.

Right: Flangeless Taper Bush sectioned to show construction. In the housing flanges develop under compression.



★After exhaustive testing Ford Motor Company Ltd. now fit Silentbloc Flangeless Taper Bushes in the I.F.S. of the "Consul" and "Zephyr Six".

Left: Front Suspension of the "Consul" and "Zephyr Six".

Flangeless Taper Bushes and Frustacon mountings provide the first complete and scientifically designed rubber insulation between wheel and body.

DESIGNERS AND MANUFACTURERS OF RESILIENT UNITS FOR MORE THAN **25** YEARS

SILENTBLOC LTD.

VICTORIA GARDENS

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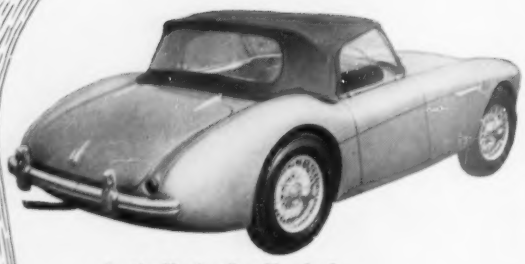
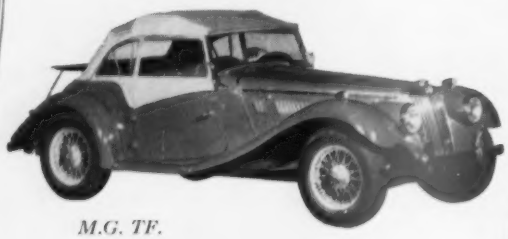


Austin-Healey One Hundred.



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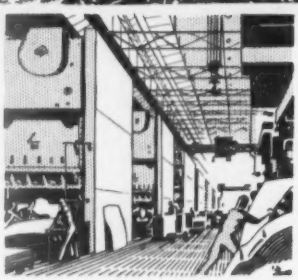

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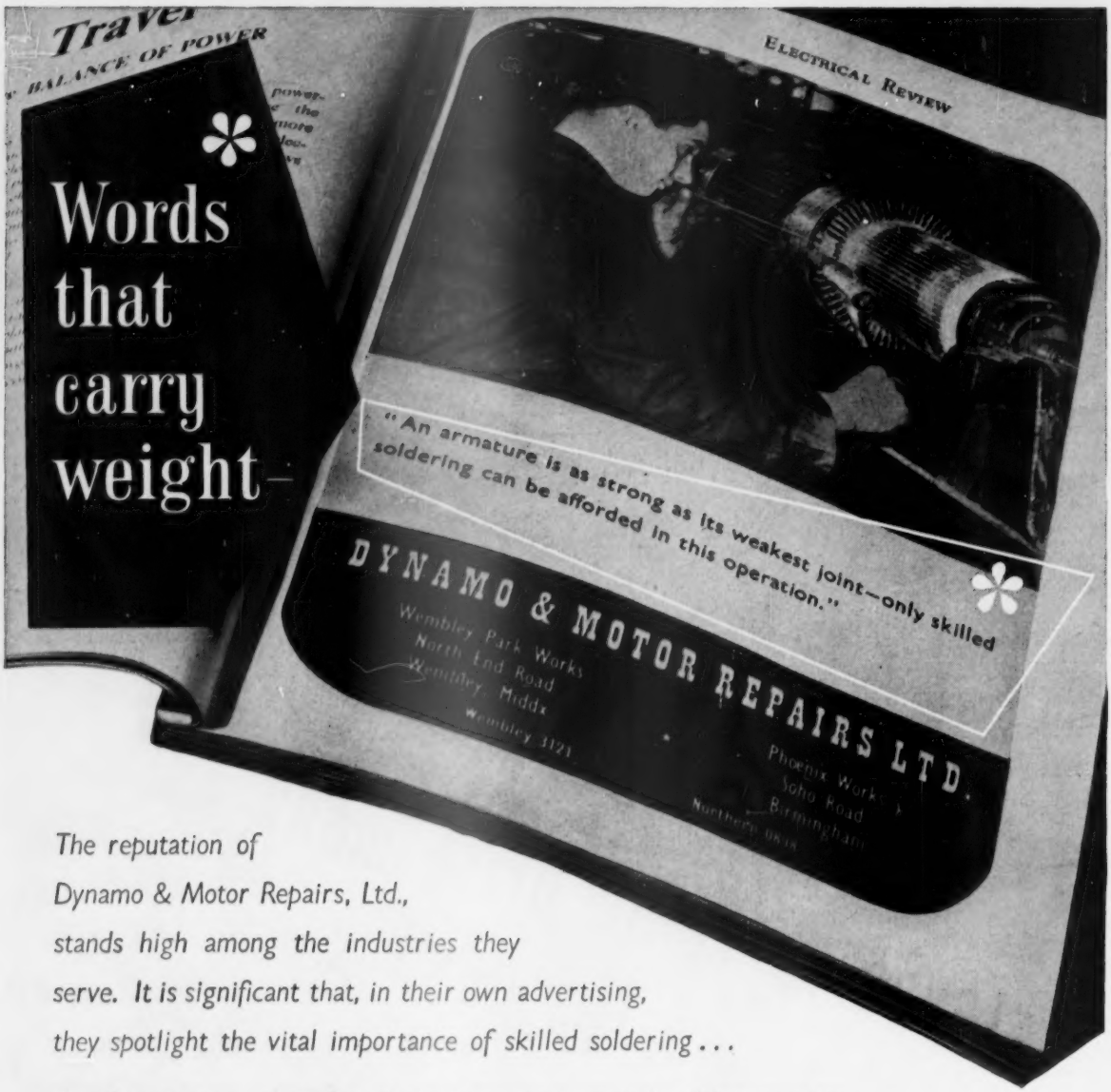

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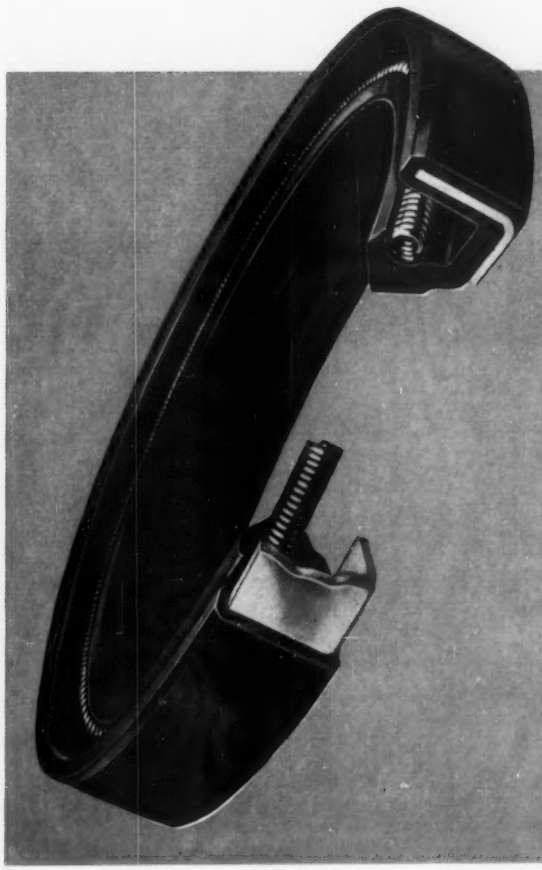

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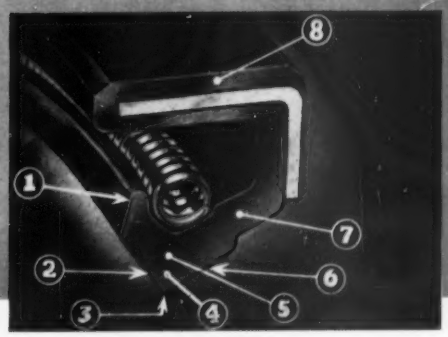

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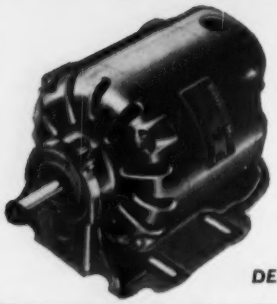
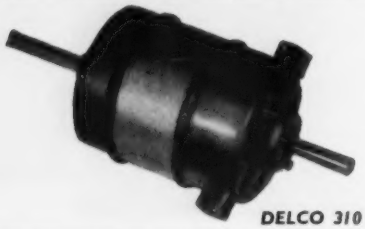
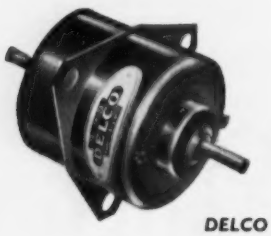


DELCO 6½" TYPE



DELCO 310 TYPE



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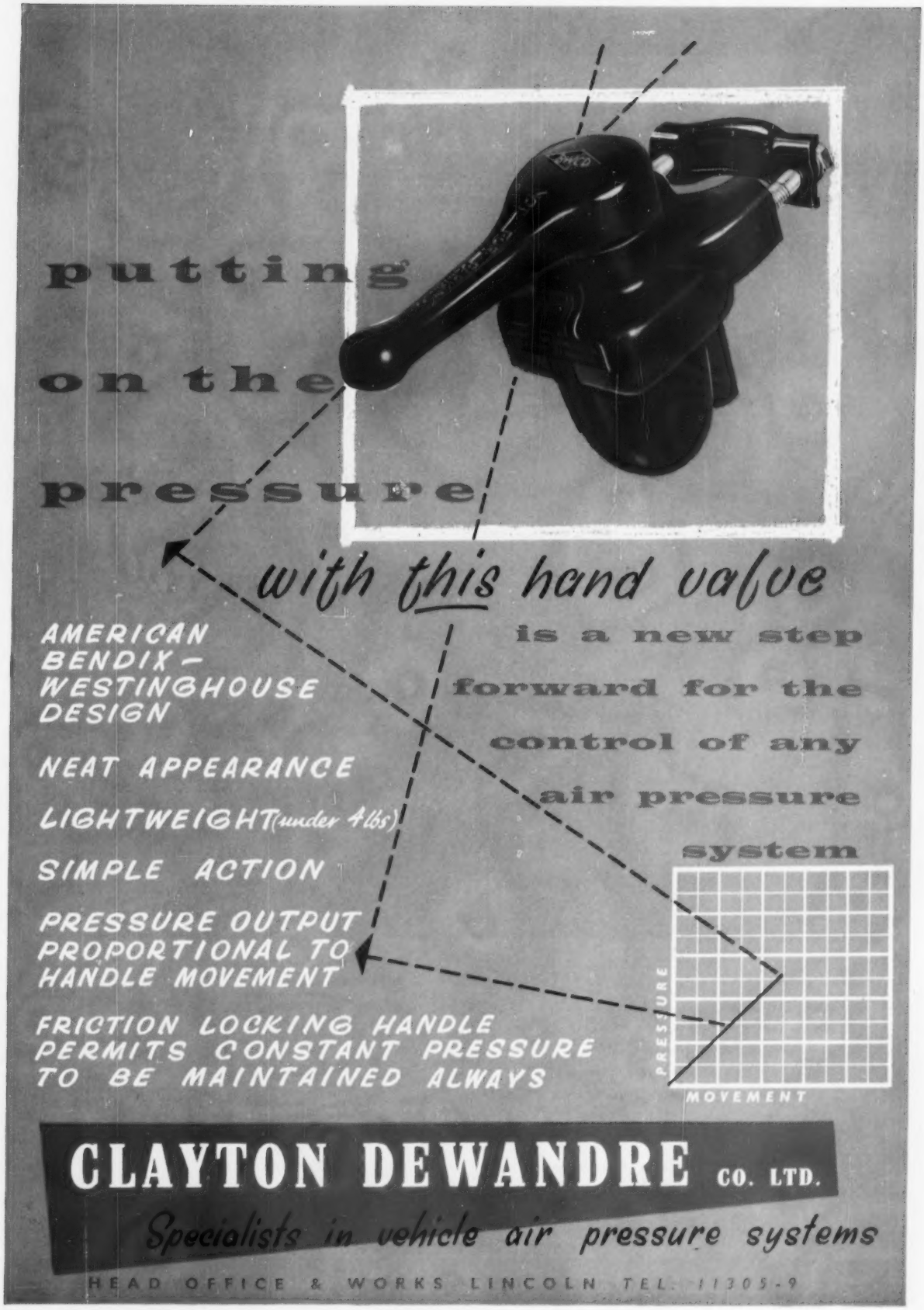
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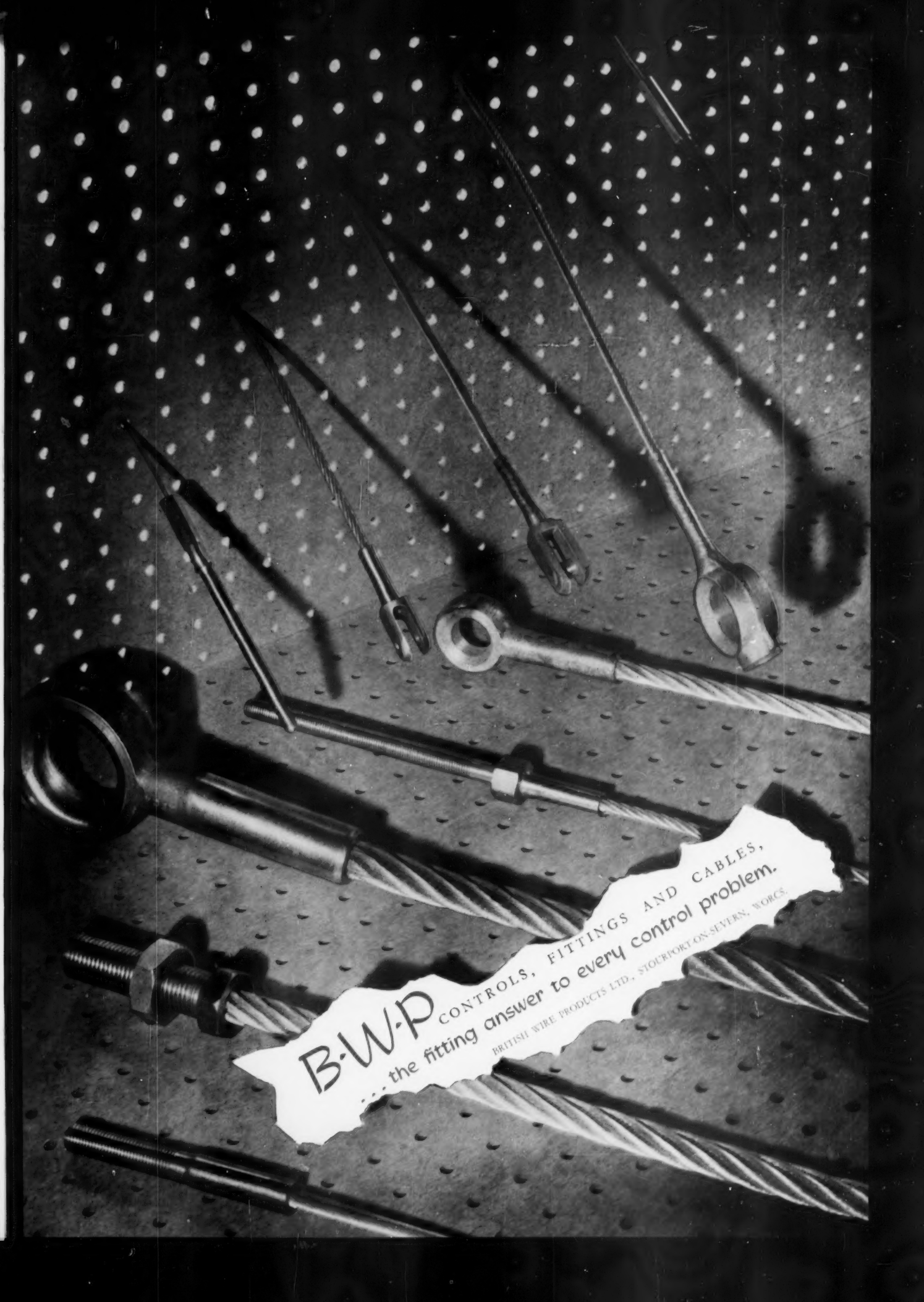
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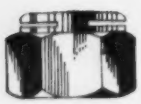

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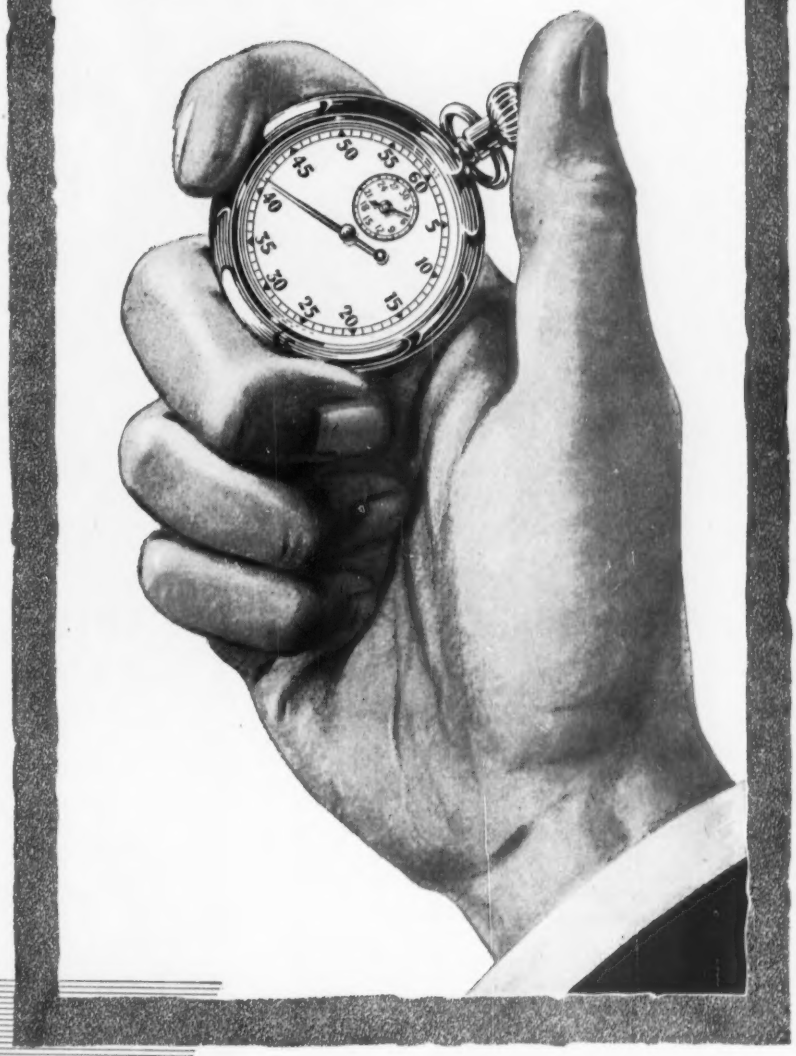

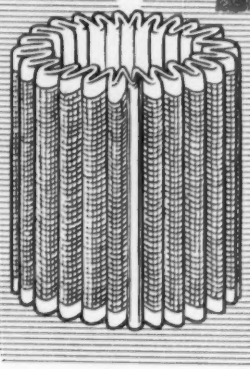

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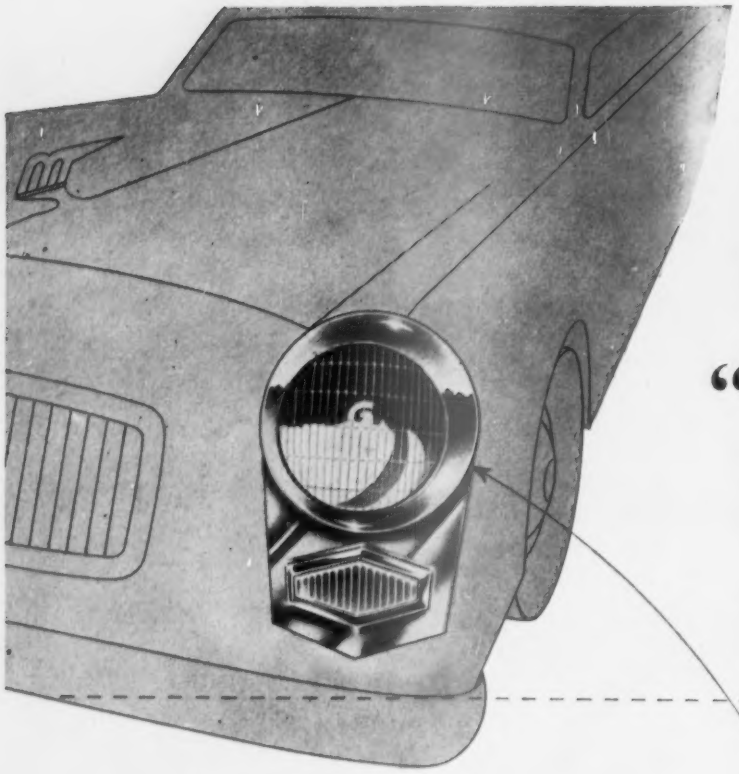

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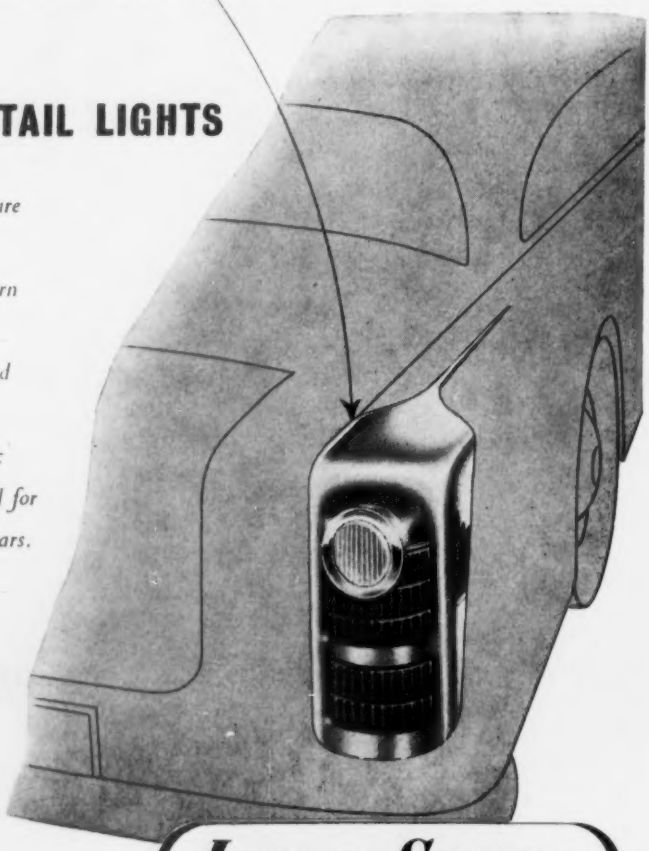

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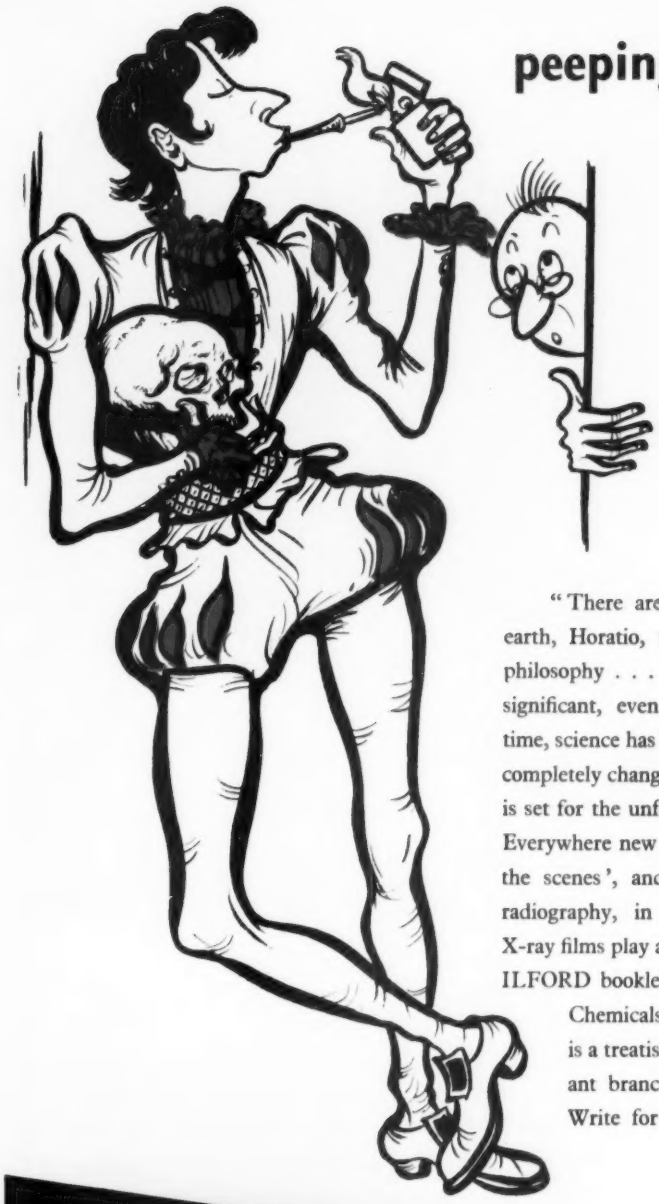

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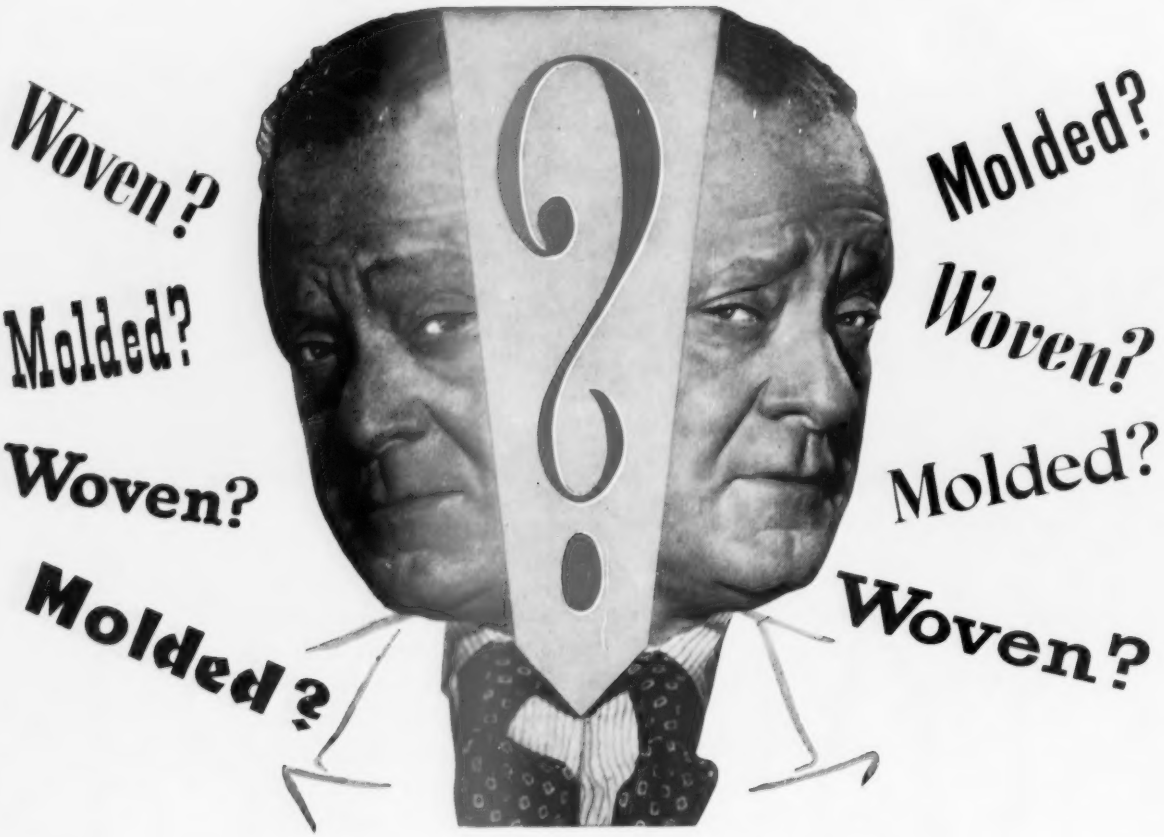

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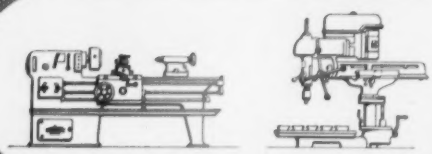

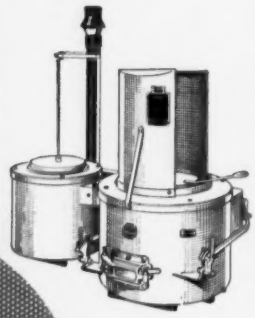

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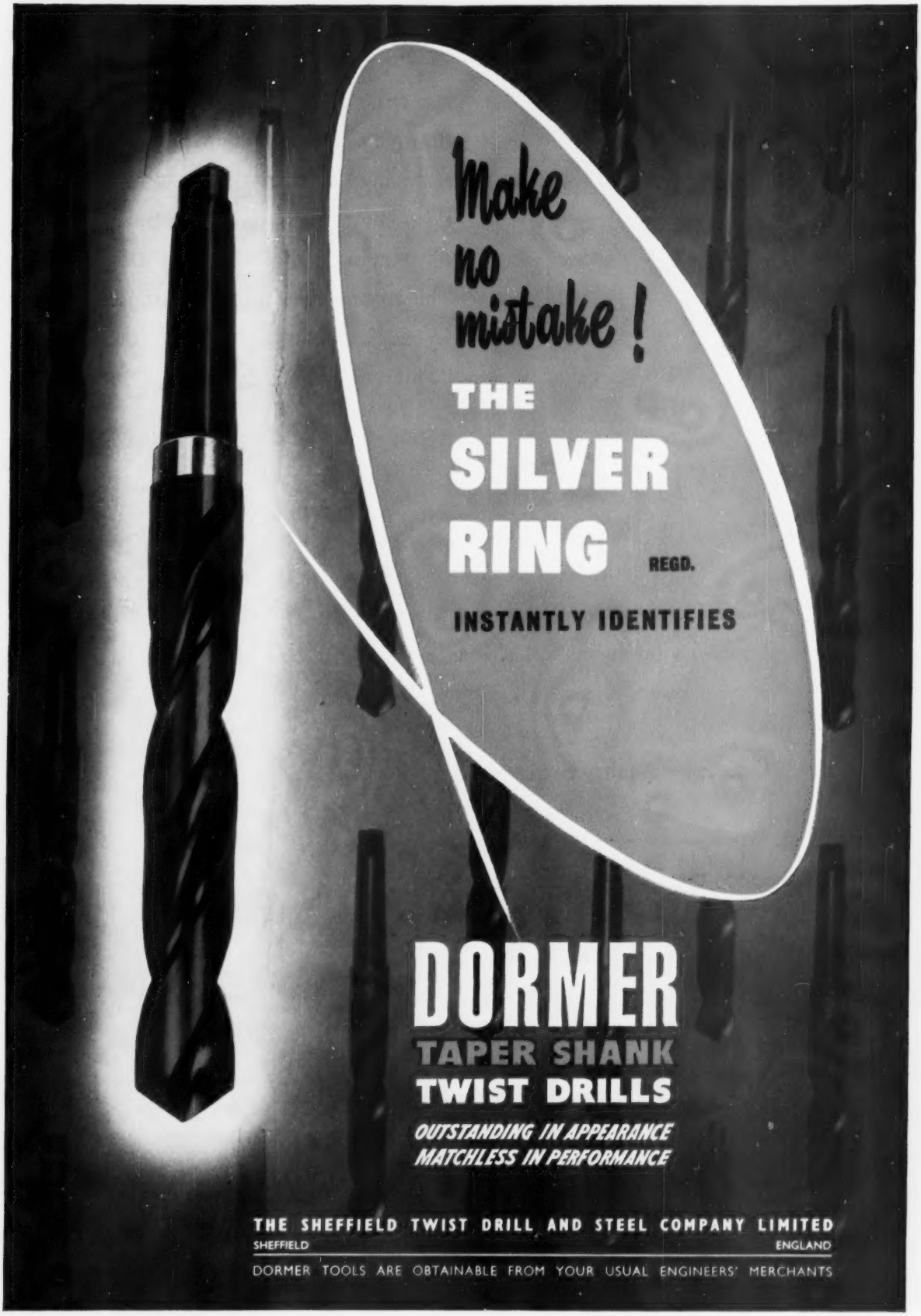
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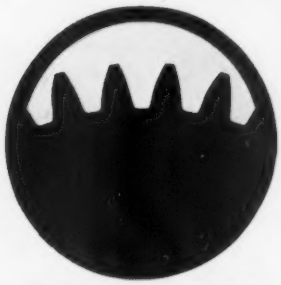

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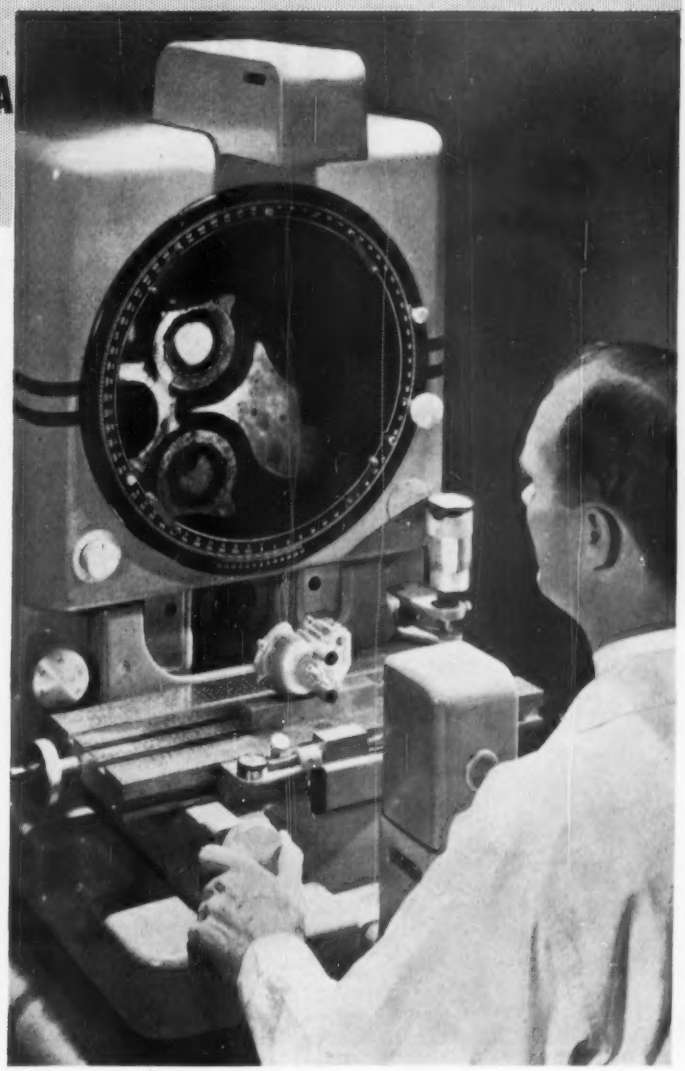

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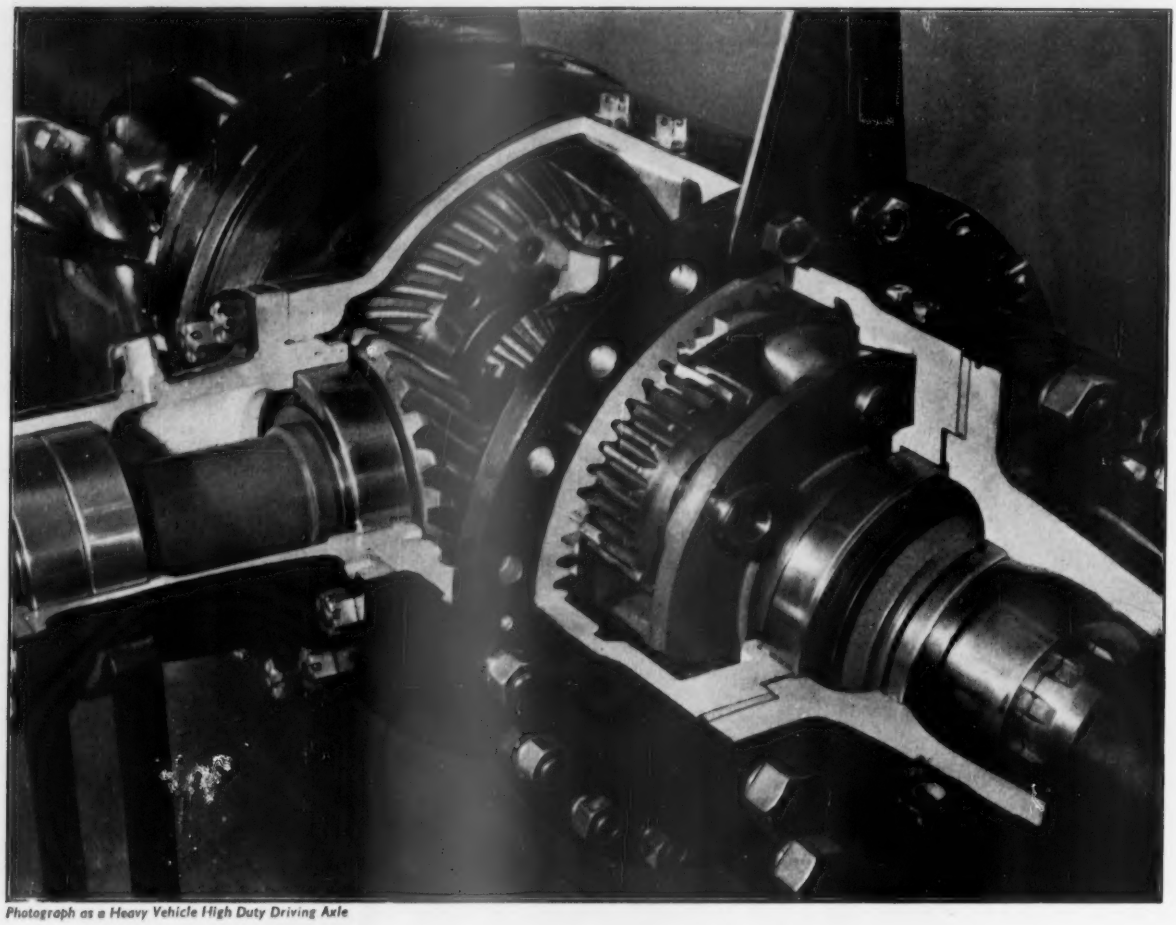

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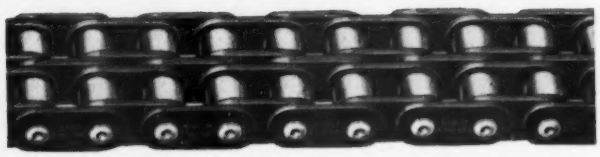

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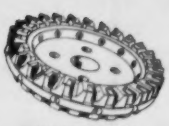

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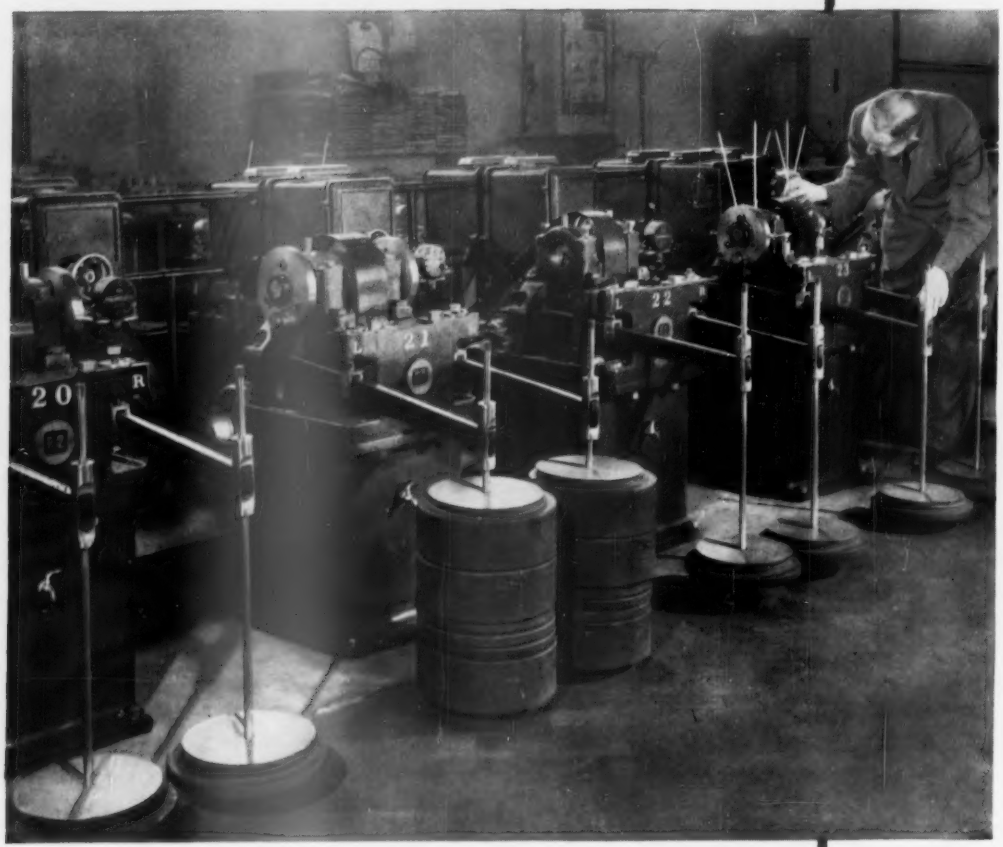

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AUTOMOBILE ENGINEER

Design, Materials, Production Methods, and Works Equipment

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American Design Trends

THERE is no immediate prospect that the automobile industry of the United States of America will be able to extend the export markets in which it competes against British and European products, but it should not be forgotten that only economic reasons limit the competition. The developments in the American industry during the past year clearly show that but for the fact that in many parts of the world dollars are not available for the purchase of motor vehicles the competition would have been very fierce and difficult to counter. Despite this, American trends must be of great interest to the British automobile industry.

The announcements of the new models for 1955 show that the 'power race' is to continue. Knowledgeable Americans, however, suspect that there is more of sales appeal than there is of real technical advance in the very high maximum b.h.p. now claimed for many American power units. There is no doubt that under special conditions these engines will deliver the horse-power that is claimed, but there are good reasons for doubting whether the quoted b.h.p. has any really effective meaning in practice.

Engine Characteristics

This search for higher maximum b.h.p. has brought troubles in its train. A high peak output per cm^3 of swept volume seems in many units to have been obtained by modifications that give a poorer torque curve in the lower speed range, with maximum torque occurring at considerably higher speed. As a result, acceleration and pulling power in the lower speed range have been adversely affected.

Another point that has been noticed with some of the engines that give a very high power per cm^3 of swept volume is that the running at what have hitherto been considered normal idling speeds is no longer smooth. Certain authorities consider that for smooth running idling speeds in the order of 700-800 r.p.m. are necessary. With hydraulic automatic transmission, which apparently every American car will have before long, idling speeds of that order create a creep problem, which will probably entail some transmission modification. Engineers generally will consider that to worsen the torque curve at speeds up to 2000 r.p.m. and to create idling problems is too great a price to pay for a high power output per cm^3 of engine displacement and an increased maximum power output of doubtful practical advantage. However, there is not the slightest doubt that at present high maximum power output has outstanding sales appeal in the U.S.A.

Another major divergence from British and European practice is the range of extra mechanisms available even for cars in the low-price class. For example, the 1955 range of cars to be produced by Ford Division of the Ford Motor Company of America can have power steering, vacuum-type power brakes, power lift windows and power effected fore-and-aft and up-and-down movement of the front seats. These all add to the cost of the car, and may in sum add appreciably to the total weight of the vehicle. Whether they are worth the extra expense and weight is a matter of opinion. Even some Americans are beginning to wonder whether gadgetry has not been carried too far.

Body Styling

So far as body styling is concerned, the 1955 trend seems to be towards more ornamentation of a type that will not have a wide appeal in this country. On the other hand the almost universal adoption of the wrap-round windscreen in conjunction with narrower front pillars to give better vision from the driving seat will at first sight appeal to many motorists. The claim is made for some models that all blind spots have been eliminated, but cynics have been heard to say that the blind spots have merely been moved to new positions. Inspection of some of these cars at the Paris Show suggests that there is a good deal of truth in the cynicism.

The very wide range of choice offered to potential owners must be mentioned. It is a great change from the policy that was current in the days of the T model Ford. To-day, the Ford Division of Ford Motor Company announce for 1955 four new lines with 16 body styles and a choice of 13 single-tone and 36 dual-tone exterior finishes, in addition to a series of optional extras.

Special Purpose Machines

PRODUCTION engineers in the automobile industry will find much of interest in the paper "Automation—its implication for management" prepared for the recent European Management Conference organized by The British Institute of Management. The paper, by Monsieur Pierre Bezier of the Renault organization, is dealt with fully elsewhere in this issue; here we are concerned only with one aspect, the maintenance of special transfer machines.

Many engineers will no doubt be surprised to learn that within the Renault organization it has been found that relatively the maintenance charges for special machines are 70 per cent less than those for standard machines. In round figures, the factory in question employs 1,200 standard machines and 200 special machines, and in terms of output the two classes are of approximately equal importance. Maintenance and repair require a staff of 66 for the standard and of 21 for the special machines. Although there is one maintenance engineer for 10 special purpose machines and one for 18 standard machines, in terms of maintenance charges per unit produced, the balance is greatly in favour of the special machines.

This result is contrary to what has generally been accepted in this country as the probable consequence of employing transfer machines. Here it has been commonly thought that because of the greater complexity of transfer machines, the maintenance charges would tend to rise rather than fall, but it was known that savings in other directions would much more than compensate for this.

Standardization

It is well worth while to consider why the maintenance charges in the Renault factory are lower for special than for standard machines. Undoubtedly the greatest single factor is that Renault design and build their own special machines. Because of this they have been able to achieve a much greater degree of standardization than would probably have been obtained had the machines been designed and built by several unrelated organizations. Owing to the large degree of standardization that has been carried out, the maintenance engineers have to be conversant with only a relatively small number of mechanisms. Consequently they have a thorough knowledge of the machines and have no difficulty in diagnosing the causes of any troubles that do occur. Another advantage is that it is a simple and not expensive matter to carry adequate reserve stocks of machine movements and parts that are likely to call for replacement. This means that all common breakdowns can be rectified with the minimum of delay.

Originally, Renault undertook the design and fabrication of their own special machine tools for two reasons: first, they had not the funds available to buy them from sources outside France, particularly the United States of America; secondly, the French machine tool industry, which is not large, had not the resources or the capacity to produce the machines for a reasonable delivery date. However, the results obtained from the first machines were such as to encourage an extension of the scheme.

Austin Developments

More recently, The Austin Motor Co. Ltd. have adopted a somewhat similar policy, but not for the original Renault reasons. The Austin policy was adopted purely as a matter of production engineering, which may be defined as the science of producing to a specified standard of quality at the lowest possible cost. The Austin machining heads are much simpler, and therefore cheaper than the machining head for the average standard machine tool. This is only to be expected since each Austin head is intended to be used on one component for very long runs, and therefore there is no need for relatively elaborate and complex mechanisms for rapid changes of feeds and speeds. These heads also have the advantage that they are easily adapted for different classes of machining operation. As a result, changes in design which lead to changes in production operations do not make the machining heads redundant, which frequently occurs when standard machine tools are used.

Future Policy

Whether it would be a good policy for all the large scale producers in the automobile industry to develop their own simple forms of standardized machining heads is open to argument; we think it would be mistaken. Such a policy could have unfortunate repercussions on the machine tool industry, and anything that weakens that industry would be gravely to the disadvantage of the automobile industry and, indeed, of the country. There is, however, much to be said for the development, preferably within the machine tool industry itself, of a range of simple standardized machining heads. Such a development could be of great value to both the machine tool industry and to the automobile industry and its ancillaries.

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CUMMINS PT FUEL INJECTION

A New Combination of the Common-rail and Mechanical Systems

THE series of automotive diesel engines manufactured by the Cummins Engine Company, Inc., of Columbus, Indiana, U.S.A., were described in *Automobile Engineer*, February, 1954. These Cummins engines are now being fitted with a recently developed fuel injection system, in which the method of metering the fuel is completely new.

A central fuel pump and separate, mechanically-operated injectors are still employed, but the functions of the fuel pump are changed and the injector unit has been given new duties to perform. The new injection system is interchangeable with the old as a complete assembly, but in the new pump unit, the number of parts used has been cut in half, while the weight of the pump has been reduced from 33 lb (the first Cummins pump weighed 104 lb) to only 13 lb. These notes describe the new Cummins Model PT injection system and briefly list its special advantages.

Fuel pump unit

In all Cummins fuel injection systems, including the new PT model, the pump unit is mounted on the side of the engine and is driven from the timing gear train in the conventional manner. The injector units, one per cylinder, are still mounted in the cylinder heads and operated by means of push-rods and rocker-arms from the engine camshaft; the new injectors are interchangeable with the old in mounting dimensions. To that extent, the Cummins fuel handling system is unchanged.

Turning now to its functions, in the old system the fuel was drawn from the tank, was metered and delivered under low pressure to each injector in sequence and was sprayed into the combustion chamber at the correct instant by the injector, which did all the high-pressure pumping. In the new PT system, the method of handling the fuel is considerably altered. Fuel is still drawn from the tank by means of a gear-type pump, see Fig. 1, but the output of this pump is now delivered, carefully regulated as to pressure, to all the injectors simultaneously. To some extent, therefore, the new Cummins fuel system functions much as did the old "common-rail" fuel system, once used on several slow-speed engines and on one or two high-speed engines, such as the R.A.E. single-cylinder engine and the Coatalen aircraft and (Russian) tank engine.

The pressure within the fuel delivery manifold varies both with the engine speed and load. It is first adjusted by a somewhat complex pressure-regulator valve, see the fuel-flow diagram, Fig. 2. This valve works automatically to give a predetermined rate of fuel pressure rise with increasing engine speed. Next the fuel pressure is further adjusted by means of a simple throttle valve, connected directly to the driver's throttle control pedal. Then a second throttle valve, this one under the control of the governor, further adjusts the fuel pressure so as to afford satisfactory engine idling and also to limit the maximum speed at which the engine may be driven under load. Finally, a shut-down valve is provided, which, either by manual or solenoid control, may be used to shut off the fuel completely and stop the engine.

Thus the fuel pump, instead of metering the fuel itself, as was the function of the older pump designs, now has the simpler duty of delivering clean fuel to the fuel manifold under a pressure that is carefully controlled to give a predetermined rate of pressure rise with the engine speed and a pressure level that varies with the engine load.

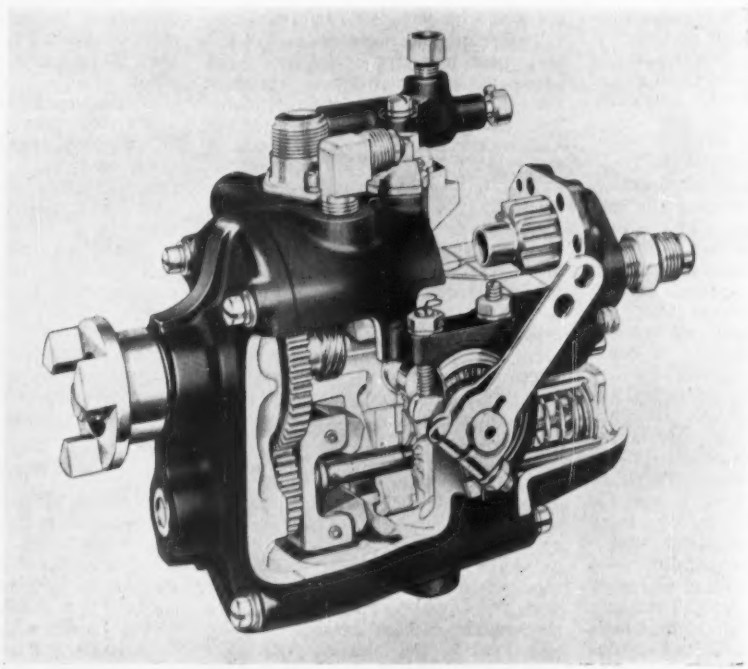


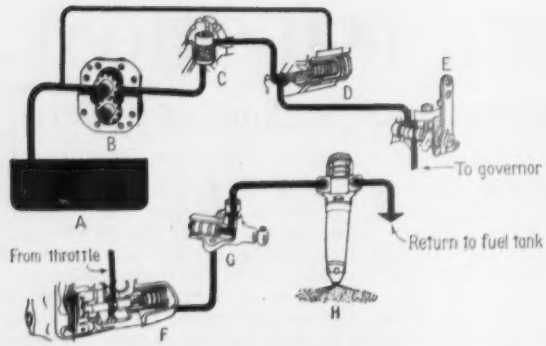
Fig. 1. The Cummins PT fuel pump

Injector unit

In the older Cummins fuel system, the function of the injector was to receive the metered fuel charge from the pump, to store it briefly while warming and mixing it with a minute quantity of air from the engine cylinder and, at the proper instant, to inject it as a spray into the combustion chamber. The new PT injector performs all these functions, but, since the fuel is supplied to it continuously, under carefully-regulated pressure, as described above, it has the additional duty of metering the fuel charges. This it does very simply by means of a calibrated orifice, which serves, in effect, to convert fuel manifold pressure and period of orifice opening (a fixed proportion of the engine cycle) into volume of fuel per injection.

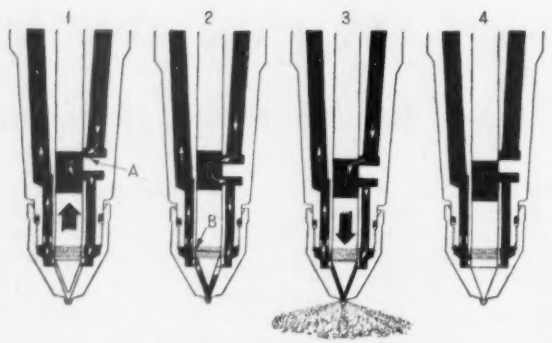
Fig. 3 illustrates the injector cycle. The fuel is delivered to the injector through the right-hand passage; for most of the engine cycle this passage is sealed off by the plunger, bottomed in the injector, as shown in the right-hand sketch of Fig. 3. At some time during the intake stroke of the engine, the plunger starts its up-stroke, port A, see the left-hand sketch, Fig. 3, is uncovered and fuel is permitted to circulate about a passage formed in the injector cap, ascending by the left-hand passage to return to the fuel tank.

Up to this point no fuel has been allowed to enter the working, or compression space of the injector. Actually, about four-fifths of the fuel that is allowed to circulate through the injector merely serves to purge the system of air or vapour and to



A—Fuel tank. B—Pump. C—Filter. D—Pressure regulator. E—Throttle control. F—Governor. G—Shut down valve. H—Injector

Fig. 2. Schematic fuel flow diagram



1—Start up-stroke. 2—Metering. 3—Injecting fuel. 4—Injection complete

Fig. 3. Fuel injection cycle

help to cool the injector. In doing so, the fuel is, of course, heated, which has been claimed as an advantage. However, this heating probably takes place too late to be of much help in preventing coagulation of the fuel during cold weather.

At some point in its upward travel, the plunger uncovers port B, see Fig. 3. This is a calibrated orifice, which serves to meter the charge of fuel into the working tip of the injector at a rate of flow which varies with the fuel manifold pressure. At the proper instant, the upward movement of the plunger is suddenly reversed, as the follower rises on the ramp of the injector cam, to inject the fuel through the nozzle drilled in the injector cap into the combustion chamber. These nozzle holes vary in diameter from 0·006 to 0·010 in and also in number, according to the engine cylinder size. Some of the fuel charge must escape back through port B, but apparently the ball check-valve, such as that used in the older Cummins injectors, is not considered necessary at this point. Finally the plunger bottoms in the injector cap, so as to expel all the fuel and thus to avoid the possibility of fuel gumming.

Pressure regulator

The presure-regulator valve, which was mentioned in describing the fuel pump, is really the heart of the new Cummins PT fuel system. Its importance warrants a brief description. When the engine is stopped and no fuel is flowing from the fuel pump, the regulator valve is seated. When the engine is running and fuel is being delivered by the pump, pressure builds up in the system, to force the spring-loaded piston valve to move out, until it has uncovered one or more of the three ports drilled in the valve spindle. At idling speed only one of the three ports is uncovered; fuel passes out through this port, to be by-passed back to the intake side of the pump.

Should the engine throttle be opened and the engine speed increased to about 1,000 r.p.m., the fuel pressure naturally builds up until the single port can no longer handle the surplus fuel. The regulator piston-valve then moves out further and uncovers a second port. Should the engine speed be still further increased, until the high-speed governor finally cuts in, to prevent engine operation at any higher speed at full load, the fuel pressure rapidly increases until the regulator piston-valve is forced to the full extent of its travel and the third and last port is uncovered. The three ports are now acting as a safety-valve, to limit the maximum, no-delivery fuel pressure within the pump.

An ingenious detail in the design of the pressure-regulator valve is a plastic rod, placed within the hollow piston-valve so as partially to block the first of the three ports. The control valve is calibrated by adjusting this plastic rod endways, by means of shims. Furthermore, the material of the rod has a high rate of thermal expansion, so that, by increasing its length when hot, it serves to compensate for the more rapid flow of the fuel through the port, as the fuel viscosity is reduced with increasing temperatures.

The shape and pressure level of the fuel pressure versus engine speed curve varies somewhat in different sizes of engines. Thus the fuel manifold pressure corresponding to the maximum full-load governed speed of the engine is 132 lb/in² in the NH models and increases to a maximum of 158 lb/in² in the NHRS models. Among the advantages claimed for this type of pressure-regulating valve are: it provides maximum fuel flow to the injectors at engine cranking speeds; it assists the engine governor by providing a steady fuel pressure at idling speeds and, of great practical importance, it makes possible the use of a single basic fuel pump on a series of engines ranging from 60 to 300 horsepower.

It will be appreciated from the foregoing description that the new Cummins PT fuel system is difficult to classify. Like the "common-rail" system, it has a fuel pump and a pressure-control valve which act together to fill the fuel lines with fuel under a more or less constant pressure. As with the General Motors Corporation Type 71 fuel injection system, the fuel is circulated to the injectors more or less continuously and the injectors pick out what they need for each fuel charge and allow the remainder to return to the fuel tank. Unlike the G.M. system, the Cummins system relies upon a calibrated orifice in the injector to meter the fuel, while the G.M. design depends for this function on the conventional relieved plunger and ports cut in the injector barrel, with accompanying somewhat vulnerable control gear.

It would appear that the Cummins PT fuel system may lend itself to the injection of petrol in spark-ignition engines. If it were used to handle petrol, however, it would probably be necessary to permit the fuel to circulate through the injectors continuously, by leaving out the cut-off ports (hole A in the injector cycle diagram), to avoid trouble with vapour. Again, the rapid ejection of petrol, through metering hole B, as the plunger starts to descend on its working stroke, might well cause enough difficulties to warrant the reinstatement of the ball check-valve, formerly used in all Cummins injectors at this point.

It is claimed for the Cummins PT fuel system that it has the advantages of simplicity, cheapness and ability to meter the fuel accurately at high speeds. Furthermore, it is claimed to be a simple matter to set the regulator valve so as to deliver at any given engine speed the maximum charge of fuel per cycle that the combustion chamber can profitably handle to a given smoke limit. Certainly its adaptability to a wide range of engine sizes is a very great commercial advantage. It is an ingenious device and one that will be watched in service with keen interest.

Springs

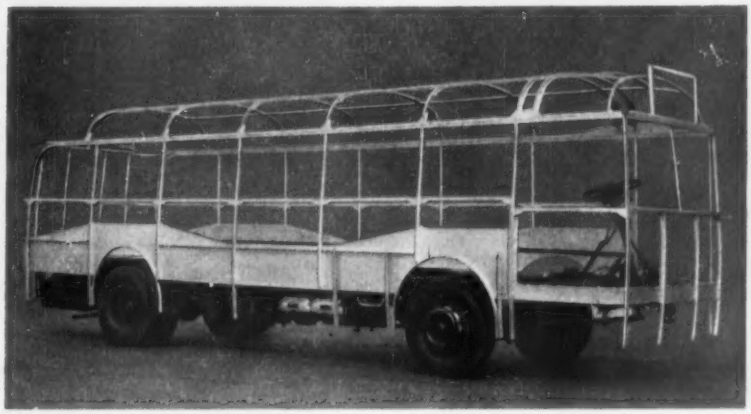
A BOOKLET, available on request, on springs has recently been produced by The Lewis Spring Co. Ltd., Resilient Works, Queen Street, Redditch. It is not intended for use in dealing with complex spring problems, but has been produced to serve as a guide and handy reference book for designers, buyers and users of springs.

PREFABRICATED BODY FRAMINGS

Interchangeable Components Formed from Standardized Metal Sections

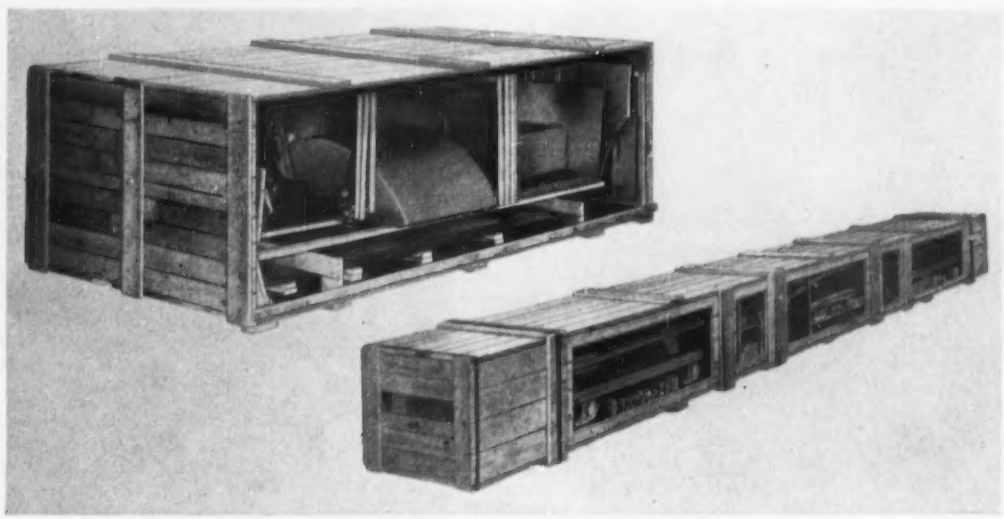
IN view of the wide range of chassis types, variation in operating conditions, specific requirements of individual operators, differing climatic conditions, and lack of uniformity in licensing and legal regulations, the bodies of public service passenger vehicles are commonly "custom built." Only exceptionally is a particular body ordered in substantial quantities and more generally individual orders are for quite small numbers. As a consequence it is impracticable to build on a continuous system and bodies are usually produced in batches.

For the export trade bodies must commonly be shipped in the knocked-down condition to save transport costs and must be capable of accurate assembly by a minimum of skilled or even wholly by semi-skilled labour. Even in the home market this practice is widespread amongst the larger operating companies and municipal authorities with the object of keeping their maintenance departments at full strength and fully employed. To satisfy the varied specifications while at the same time establishing a strict interchangeability of parts in each particular type of body presents many difficulties. The basic design must be capable of a considerable measure of dimensional and styling modification without affecting the strength and rigidity of the stressed structure. Furthermore, such modifications must not involve any substantial increase in weight or unduly raise production costs.



Low floor, 44-seat, single-deck framing on Leyland "Tiger" chassis

The policy of prefabrication evolved by Metal Sections Ltd., of Oldbury, Birmingham, meets these requirements admirably under present-day conditions. The firm supplies a metal framing, built up of interchangeable parts formed from standardized sections, in the completely-knocked-down (C.K.D.) condition. If desired, for the export market, all other necessary materials and interior and exterior fittings and components can be supplied to complete the bodywork. Alternatively, framings can be delivered in units, comprising floors, roofs, sides and ends ready for bolted assembly on the chassis. Metal Sections Ltd. are not body builders but manufacturers of prefabricated sets of framings and body materials, and do not undertake the production and mounting of complete bodywork. The only exceptions to this policy occur in the assembly of special prototype or development bodies for the purpose of proving the drawings and jigs. The customer who will subsequently erect, mount and finish from prefabricated parts is thereby assured that no trouble will be



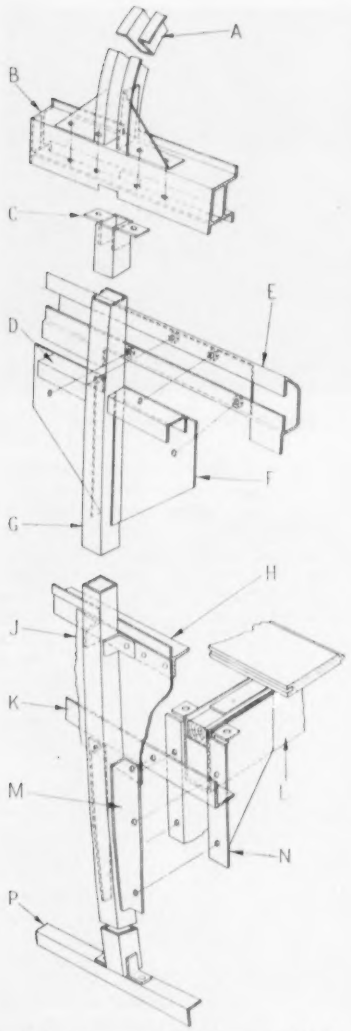
C.K.D. framings and all parts for complete bodies are packed for export in standard cases. This represents the packing of a 33-seater single-deck bus body in 175 ft³ or 4·95 m³

The largest gang-slitting machine handles coiled strip up to 3 ft in width

General view of cold-rolled section department

Main fabricating and experimental assembly shop

Prefabricated double-deck bus components being collected and bundled for dispatch



A—Roof stick, m.s. section (alternative, 1½"×1"×18G m.s. tube); B—Cant rail, l.a. extrusion; C—Pillar top knees, 1½"×1½"×⅛" h.r. angle; D—Waist rail, m.s. section; E—Garnish rail, l.a. extrusion; F—Garnish rail flare, 16G m.s. plate; G—Main pillar, 1½"×1½"×16G c.m. steel tube; H—seat rail, l.a. extrusion; J—Truss panel, l.a. or m.s. plate; K—Sole bar, 1½"×1½"×⅛" h.r. angle; L—Cross bar, ·35 carbon steel section and inner m.s. section; M—Pillar-cross bar angle, 1½"×1½"×⅛" h.r. angle; N—Cross bar-pillar bracket, 10G m.s. plate; P—Valance, rail, m.s. section

Standard construction for single-deck bus

encountered in assembly. As regards the adaptability of the design, the illustrations on another page of typical single-deck buses with bodies built on Metsec framings show that vehicles can be harmoniously and individually styled to suit the chassis and the operator. There is no suggestion of the design and the method of fabrication enforcing an ungainly uniformity.

Framings are of metal and no wood is employed for stressed members. Particularly in overseas markets the trend is towards the all-metal body, though the wooden floor is still widely used. At home, wooden fillers are frequently used in the metal sections to permit the attachment of panelling by means of wood screws. Traditional practices and the craft demarcations of the trade unions are important factors in this connection. There is no attempt to insist upon an "all-steel" or "all-light alloy" framing. Cold-rolled steel sections, solid-drawn steel tubes, light alloy extrusions, light alloy or mild steel truss plates, and light alloy panels are used. Apart from the rolled sections, which are commercial quality mild steel, all the materials are produced by companies associated in the Tube Investment group. Cold-rolled sections are by Metal Sections Ltd., structural tubes and tubular seat frames by Accles and Pollock Ltd., and light alloy extrusions and panels by T.I. Aluminium Ltd.

For the body builder this method of construction offers a number of advantages over the traditional timber framed and composite designs:—

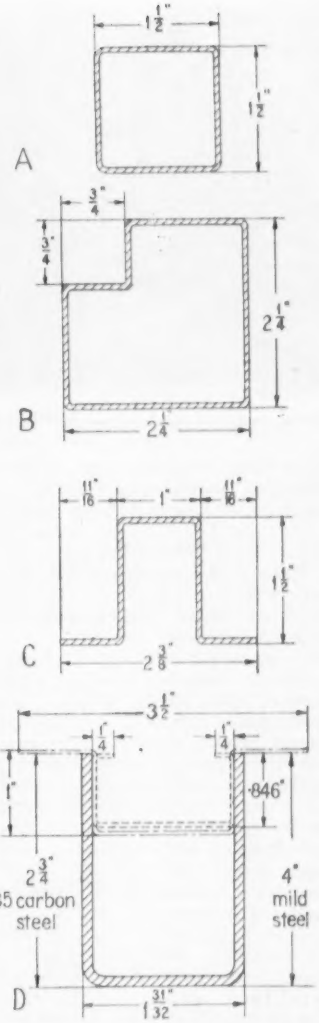
1. Reduction of weight.
2. Reduction of erection time.
3. Only semi-skilled labour required.
4. Interchangeability of component parts.
5. Reduction of time and cost of repairs.
6. Lower freight charges.

The range of framings produced includes virtually all types of passenger and goods vehicles, electric vehicles, shooting brakes, station wagons and trailer caravans. Single-deck bus and coach framings may be of full-fronted, half-cab, or normal bonneted types with forward, centre or rear entrance/exit as required. Full-fronted or half-cab double-deck bus framings have a similar choice of door locations.

Production

Although the Company rolls sections for a number of industries, about 50 per cent of its output is for automobile and allied manufacturers. Stock material is received from the steel makers in the form of coiled strip in various widths up to a maximum of 3 ft. In some instances, for simple channels and angles, for example, the strip is purchased slit to size and is issued direct to the rolling mills. These strips are held to commercial limits. For the more intricate sections, however, closer limits on the width are necessary and wide coils are specially slit to produce a number of narrow strips, each held to an overall tolerance of $\frac{1}{64}$ in. Slitting operations are carried out in a battery of gang slitting machines, the largest of which can handle coils up to 3 ft wide and weighing from 4 to 5 tons.

From the slitting machines the recoiled strips are conveyed by fork truck to the cold rolling machines. All of these, with a few exceptions, are of the firm's own design. Most have twelve main and three final spindles, and the usual intermediate correction and guide rolls to prevent rippling of the part-formed section. As will be seen from the illustration, the rolls are overhung to facilitate the rapid change of rolls, quick set-up of the machine, and continuously visible operation. All rolls are designed, machined and

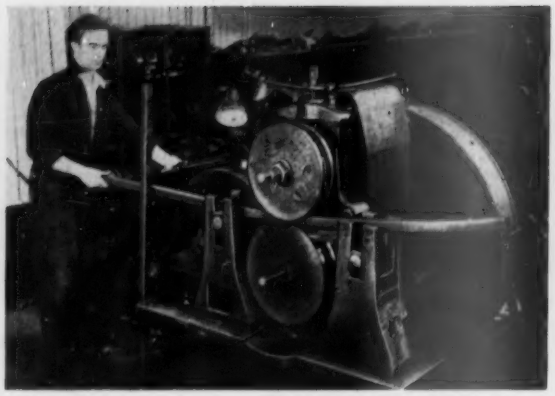


A—Side pillar, chrome molybdenum, 16G for S-D, 16G lower and 18G upper for D-D buses; B—Bulkhead corner pillar, chrome molybdenum, 16G; C—Roof stick, mild steel, 16G; D—Cross bar, 2¾ in deep, ·35 carbon steel, 4 in deep, mild steel, 10G. Inner sections, 18G mild steel

Standard steel sections

finished in the firm's tool department.

From each rolling machine the section runs down a ramp 100ft long and at the end operates an electrical trip device which shuts off the motor and stops the rolls. The section is then parted by a manually operated, swing type, cut-off saw mounted at the finishing end of the rolling machine, and the operation is repeated. At the end of each ramp is a shearing press on which the section is cropped into working lengths ready for fabrication. Shearing tools are available for all standard sections but special sections or short runs are cut on a band saw. The working length, it should be noted, is a standard length that covers all requirements for a particular component. Any adjustment required to meet individual specifications is made by trimming during fabrication. Tubes and light alloy extrusions supplied by



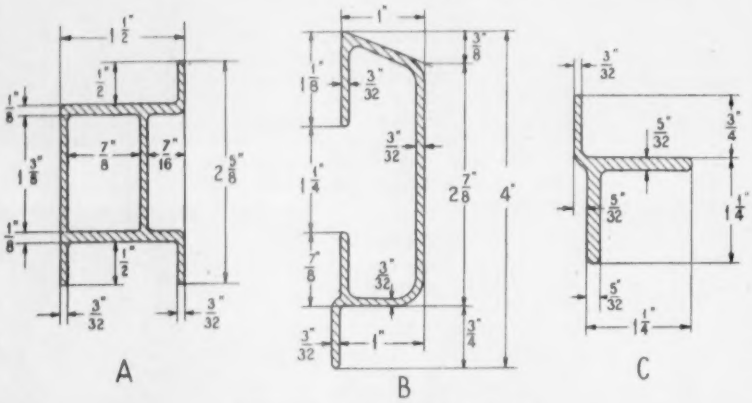
Special sweeping machine for contouring pillars and roof sticks

Checking a tubular pillar for correctness of sweep

other firms are ordered in estimated multiple lengths and are cut to standard working lengths as required.

Fabrication

Tubes and sections are wheeled to approximate contour on a special power-operated, push-button controlled sweeping machine. This comprises superimposed rolls, of appropriate peripheral profile to suit the section, flanked on each side by slider blocks adjustable for height and angle to produce the desired curvature. The component is checked for accuracy of sweep on a metal template and should any correction be necessary the section is marked, given a blow in a fly-press, and rechecked. Tubular main pillars, swept on this machine, are then cut to precise length and taken to a welding booth. There they are mounted on a jig and standard attachment brackets for the crossbar, seat rail, waist rail and cant rail are arc welded in position. In the standard construction all brackets are welded but in special cases where a bolted attachment is specified the necessary holes are tubed and welded to prevent possible distortion of the section on assembly.



A—Cant rail; B—Garnish rail; C—Seat rail

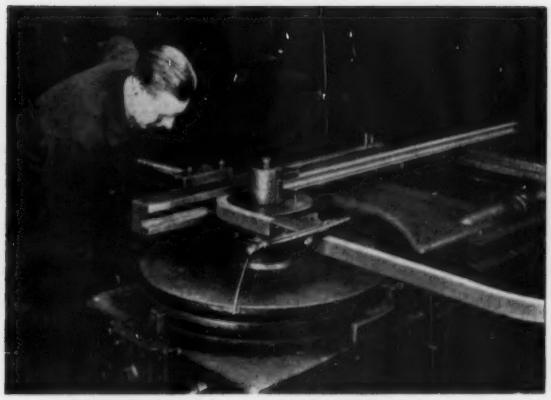
Standard light alloy extrusions

Straight longitudinal members, such as cant rails (when of steel section), waist rails and valance rails, have their attachment brackets tack-welded in position on a jig, are removed for arc welding and finally checked on the jig. Some brackets are produced from plate by cutting to shape on guillotines and folding in a press, others by blanking in a power press, and simple angle brackets are sawn to length from hot-rolled stock.

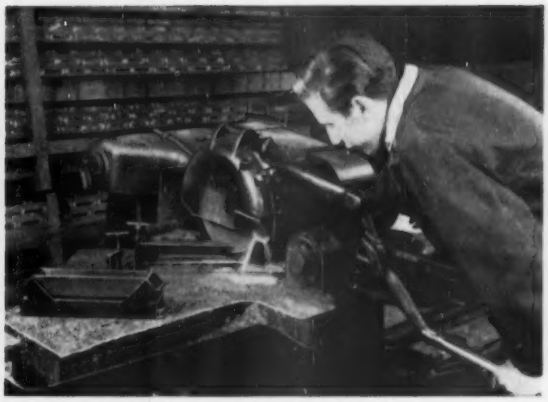
Cross bars are formed from either a $2\frac{1}{2}$ in deep channel section of 0·35 carbon steel or a 4 in deep channel of mild steel. Each is in 10G material and is closed by an 18G channel section spot welded in position. For wooden floors this light channel is of box section to accommodate a wood filler, while for metal floors it is formed with wide flanges. Bars are cut to length, drilled

Welding jig for pillar attachment brackets

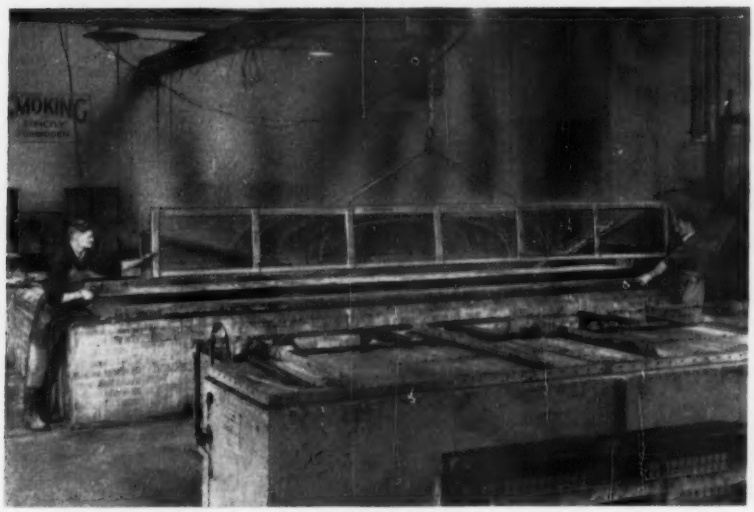
Rotatable jig for welding pillar and chair brackets to cross bar



One of a battery of special bending machines



Cold-rolled sections for welded brackets and frames are cut on a circular saw machine



Degreasing, pickling and Granodizing fabricated components

for the floor longitudinals, and pillar connection brackets are arc-welded in position in a rotatable welding jig. When required, chair brackets to raise the cross bar above the vehicle side frames are also positioned and welded in this jig, as may be seen in the illustration.

For simple roofs a 16G top-hat section is employed but when roofs are to be racked and used for load carrying, additional strength is required. In some instances a reinforcing strip is spot-welded inside one limb of the top-hat channel; alternatively, a $1\frac{1}{2}$ in $\times$ 1 in $\times$ 18G tube is used. Three sweeping operations are required to form the roof sticks, first the main transverse contour and then the two radiused ends, which are checked for conformity to a metal template. After trimming to length, standard gusseted brackets for attachment to the cant rail are jig located and spot-welded to the ends.

Wheel arch framings of plain angle or channel section are also produced by sweeping and jig welding. In some instances stainless steel is employed for the wheel arches. Small-radiused bends in the lighter sections are made on a battery of hydraulic bending machines, also specially designed to the firm's requirements. The work is clamped tangentially to the forming roll keyed on the driven vertical spindle and held to the roll by a suitably profiled slidable support bar. The rotating table is indexed and its periphery is grooved for the attachment of stops to actuate an automatic trip control. Such items as knee brackets, cross bar chairs and parts for bulkhead framings are cut from cold-rolled sections or tubes on an angle sawing machine and checked for length in simple gauging jigs.

Double-deck buses follow a similar construction but the lower saloon cant rail may be a steel angle instead of a light alloy extrusion. Bulkheads are stiffly built with side pillars of $2\frac{1}{4}$ in $\times$ $2\frac{1}{4}$ in $\times$ 16 G chrome molybdenum tubing formed with a $\frac{1}{4}$ in rebate. The front bulkhead has a central pillar and a cross rail at waist level, each of a

Finished components are dipped in chlorinated rubber-aluminium paint, drained and air-dried

TYPICAL SINGLE-DECK BUSES WITH PREFABRICATED METSEC BODY FRAMINGS

Double entrance/exit service bus, Thornycroft chassis, Port of Spain, Trinidad

Single entrance district bus, Bedford chassis, Accra, West Africa

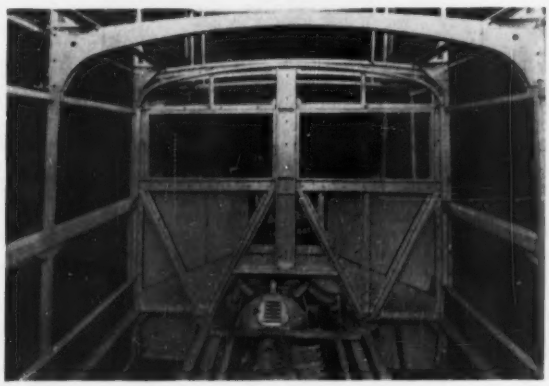
Urban service bus, Daimler chassis, Brazil

Double entrance/exit bus for local service, Guy chassis, China

Typical double-deck body on Daimler chassis for Belfast Corporation

substantial box channel section. Welded angle and channel frames brace the structure below the lights and support the transverse truss panels. At the rear, the partition incorporates the saloon entrance framing and is trussed by the mild steel riser plate.

Lower saloon arch rails are built up of upper and lower swept channels, to receive timber fillers, spaced by profiled side plates and spot-welded. Standard flanged flares, or gussets, are spot-welded to the ends of the arch rails. The side flanges bolt up to brackets on the pillar and the upper flanges provide a seating for the upper saloon pillar foot brackets. Cove panels in the upper saloon mask the pillar junctions.



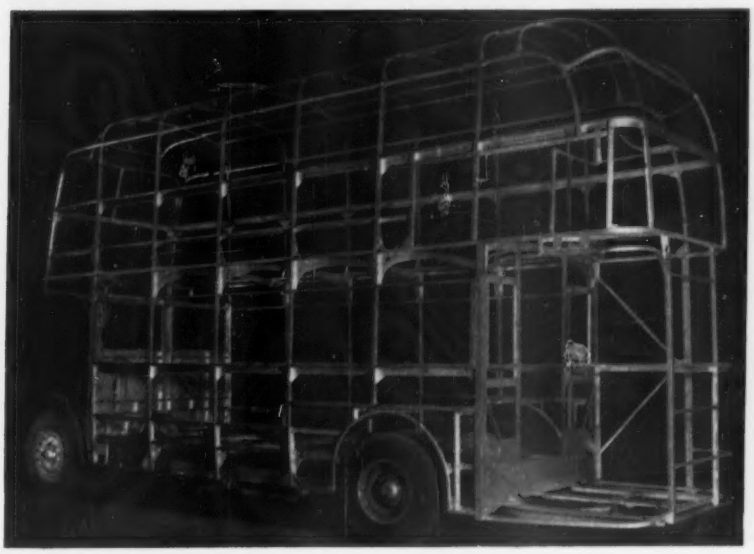
Bulkhead construction on double-decker on Leyland chassis

Roof sticks for the upper saloon may be of light alloy in plain channel section. Flanged flares, solid riveted to the roof stick, are bolted to the cant rail and pillar knee brackets. At the overhung front end of the upper saloon the corner pillars and front cross rail are formed of two light alloy channels; one looped across from side to side and the other swept back to join the cant rail. The rear platform is welded up from hot-rolled angles and supported from an angle on the base of the riser plate. Diagonal braces are fitted to the closed side of the platform enclosure. Two bays in the main structure are interrupted by the wheel arches, and these are bridged by longitudinal strengthening rails of square tube with tubed and welded holes. Truss panels of steel or light alloy, riveted to the lower saloon seat rails, sole bars and pillars, are carried over the wheel arches to the waist rails. Cold-rolled angles and sections are used for the half-cab, with a tubular corner pillar of special section rebated to receive the outer panelling. All door frames are welded up.

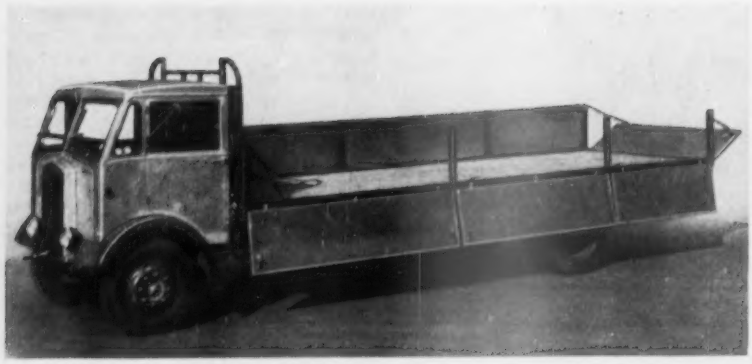
Usually the cross bars are held down to the chassis by $\frac{3}{8}$ in thick mild steel straps bolted to angle brackets on the vehicle side frames. When a relatively high floor level is required, as with certain coaches, welded chairs are used to raise the cross bars above the side frames, as already mentioned. Conversely, should a specially low floor level be demanded the crossbars can be eliminated and the framing supported from outrigger brackets bolted to the frame side members. The body framing pillars are attached to a support rail of deep angle section carried by the outriggers. This construction is followed on the 44-seat, single deck framing for the Leyland "Tiger" chassis with underfloor engine. From the illustration of this framing the method of stiffening the front end by means of a truss plate at cant rail level above the door opening may be noted. The opening is braced at the bottom by the step structure. Overall dimensions of this framing are 30 ft long and 7 ft 6 in wide and the total weight, assembled on the chassis as shown, is $10\frac{1}{2}$ cwt.

Anti-corrosion treatment

After fabrication all parts are thoroughly cleaned and given a phosphate coating by the Granodine process as a protection against corrosion. Vats are arranged in an aligned series and the work is transferred in wire baskets by an overhead electric hoist. The treatment cycle, the overall time of which will vary according to the size and condition of the batch of work, is as follows:—



Skeleton framing for Belfast Corporation double-decker on Daimler chassis



Drop-side body on Albion chassis; steel underframe, light alloy platform, steel-framed cab

1. Degreasing in trichlorethylene vapour bath at 160-180 deg F.
2. Pickle in phosphoric acid bath at 140-150 deg F to remove rust.
3. Cold water swill.
4. Hot water swill.
5. Cold phosphating bath of Granodine.
6. Cold water swill.
7. Hot water swill.
8. Drying in a gas-fired oven to remove all moisture.

After treatment the parts are given a priming coat of paint. As standard, a chlorinated rubber-based aluminium paint is used, but other primings such as an oil-based red oxide or chassis black may be specified. In all cases the parts are dip coated to ensure an adequate cover for the interior of tubular members and inner surfaces of part-enclosed or masked components. After dipping, the parts are stacked in racks to drain and air-dry.

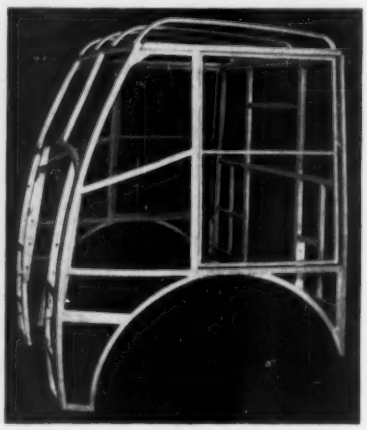
Completely knocked down shipment

A fully detailed schedule of parts is prepared for each order and from this the parts are collected and grouped for despatch. When destined for a builder in this country the parts are bundled and delivered directly by road. For overseas customers, however, the parts are cased and relatively elaborate precautions are taken to simplify the checking of the shipment on arrival and the subsequent assembly on the vehicle chassis. One complete set of schedule sheets is forwarded by air mail and, as they detail the contents of each case, the customer need open cases only as required; this minimizes the risk of pilferage. A duplicate set of schedule sheets is enclosed in one of the cases. Each part, or bundle of small parts, has attached by wire a metal label stamped with the item number and can thus be positively identified from the schedule. Against each item on the schedule is the following information:—

1. Description of part.
2. Number required for each bus.
3. Quantity sent in the consignment.
4. Balance outstanding to complete the order.
5. Number of the packing case in which the particular part will be found.

All necessary drawings are provided, including final assembly drawings of the framing with all parts identified by the schedule item numbers. A fully detailed and well illustrated instruction manual is divided into two sections, one dealing with the mounting and assembly of the framing and the other with body panelling and finishing. No assembly jigs are necessary, the structure being bolted up on the cross bars after simple alignment on the chassis. Obviously, the time required will vary according to the facilities at the site and the labour available. As an example of what can be achieved, using mainly unskilled labour, it is recorded that a State Transport Corporation in India assembled and finished several hundreds of single-deck buses at the rate of one vehicle per day.

As regards framings, complete sets of parts for three single-deck buses can be packed for shipment in three cases 8 ft×4 ft×3 ft and a single case 22 ft×1 ft×1 ft, having a gross weight of about 50 cwt. The net weight of the three sets is approximately 34 cwt. Additionally, to meet customers' requirements, the firm will supply part or all the materials and equipment needed to finish the body. Light alloy interior and exterior panels are cut to size and shaped panels in aluminium may be either ready for fitting or in the flat sheet. Tucker "Pop" rivets are used for the attachment of panels and the necessary mechanical (lazy-tongs type) or pneumatic tools for fixing can be supplied. Other structural items include glazed fixed and movable windows, windscreen, doors and door operating gear, emergency exit door, ventilators, and side and roof insulating material.



All-welded cab framing for Foden lorry

Framing for insulated box van on 4-5 ton Commer

Body equipment can be despatched so that the customer is virtually assured of no unnecessary delay in finishing the vehicle ready for service. This may include interior and exterior trim mouldings in light alloy; tubular seat frames with slatted or upholstered seats; destination indicators; electric lighting and signal fittings and the necessary wiring and switchboard; decency screens, grab pillars and interior parcel racks; trafficators, windscreen wipers and observation mirrors, roof luggage racks, ladders and lifeguards; and fire extinguishers and first-aid boxes.

The method of assembly greatly

facilitates body repairs. For example, a damaged pillar and two side panels can be removed and replaced by new parts by one man in about 30 min. The exterior panels have joggled margins and are secured to the pillar faces by a "Pop" riveted strapping. When replacing panels the rivets are drilled out and the strapping serves as a drilling jig for the new panels. It is of interest to note that the firm's experience has led to the adoption of proprietary self-locking nuts throughout the structure. Too often it has been found, particularly overseas, that loose lock washers have been omitted on assembly. Another aberration is neglect to tighten all nuts and bolts.

Commercial vehicle framings

Whilst framings for single- and double-deck buses and trolley buses constitute the main activity, a wide range of body framings for goods vehicles is also produced. A platform-type lorry body has a prefabricated underframing and a light alloy corrugated floor. As mounted on the Albion lorry illustrated, detachable stanchions and side and tail boards can be fitted to convert it quickly to a drop-side body. Also shown is a skeleton framing for a box van on a 4-5 ton Commer chassis. This example is one of a number produced for Lever Brothers and Unilever Ltd. and is finished to incorporate the "Walton" patent insulating covering. Standardized cab framings for a number of goods vehicle manufacturers are mostly of the all-welded steel type, of which the Foden cab, illustrated, is typical. Complete chassis-frame structures are fabricated for battery electric vehicles and also for trailer caravans.

RECENT PUBLICATIONS

Brief Reviews of Current Technical Books

Lubrication of Industrial and Marine Machinery

By W. G. Forbes.

London: CHAPMAN AND HALL, LTD., 37, Essex Street, W.C.2. 1954. 5¼ × 9. 351 pp. Price 52s.

The second edition of this book has been revised by C. L. Pope and W. T. Everitt. The late W. G. Forbes worked for most of his life with engine builders and machine manufacturers, in shipyards and ocean-going vessels and in industrial plants. C. L. Pope and W. T. Everitt have also had extensive experience in industry. It follows, therefore, that the book is written from the point of view of an engineer rather than an oil technologist.

The first fourteen chapters deal with the chemistry, refining, compounding and specification of lubricants, and dwells at some length on the limitations of certain types. Chapters 15-32 explain the lubrication requirements of the most common types of machinery and cover quenching and cutting oils. In this section, 39 pages are devoted to internal combustion engines and their lubricating oils. Several of the chapters are on plain, ball, and roller bearing lubrication, the formation of oil films, and machine storage and shipment. Problems associated with the lubrication of pneumatic tools, reduction gears, air compressors, vacuum pumps, hydraulic systems and fluid couplings are discussed. The remaining chapters give practical examples of how information contained in the first part of the book may be applied in practice to the lubrication of equipment.

Automobile Electrical Maintenance

By A. W. Judge, A.R.C.S.C., Wh.Sc., A.M.I.Mech.E.

London: SIR ISAAC PITMAN AND SONS LTD., Parker Street, Kingsway, W.C.2. 1954. 5 × 7¼. 256 pp. Price 12s. 6d.

The author of this work is well known as a writer of technical books. He has recently revised his work on automobile electrical maintenance to bring it up to date and the third edition has now been published. Certain of the sections and illustrations have been modified and an appreciable amount of new material has been added. The sections on magnetos and coil ignition, dynamos, starter motors and batteries have been amplified and parts re-written. The original policy of presenting the information in a simple and compact manner has been continued. As in the first edition, the subject of electrical faults, their diagnosis and remedy is given prominence.

The book is a comprehensive guide for service engineers as well as for private motorists. It begins with a description of the individual circuits that comprise an automobile electrical system, shows how these circuits are combined, and gives typical wiring diagrams. Following this are chapters on coil ignition and magnetos. A further nine pages are devoted to spark plugs. The remaining chapters deal with dynamos, starter motors, batteries, lamps and other accessories, and the last one is on locating electrical faults.

Motor Vehicle Calculations and Science

By R. C. Champion, A.M.I.Mech.I., A.M.I.R.T.E., and E. C. Arnold, M.I.M.I., M.I.R.T.E.

London: EDWARD ARNOLD (PUBLISHERS) LTD., 41, Maddox Street, W.1. 1954. 4¼ × 7¼. 202 pp. Price 7s. 6d.

This is an elementary text book for the young apprentice who is just beginning his studies. Part I deals with elementary calculations and contains sections on mechanics, heat and electricity. A knowledge of engineering drawings and the measurement of angles with a protractor is a prerequisite for the solution of some of the problems in these sections. An indication of the academic level of the book may be gained from the fact that the first chapter is on fractions, the second on decimals and the third on powers and roots.

Part II is devoted to trigonometry, algebra and further calculations and science up to the standard of the Motor Vehicle Mechanics and Technicians examinations, the City and Guilds of London Institute, and similar examinations set by other Boards. A fairly wide field is covered and the headings of the chapters include work and horse power, moments, stress and strain, heat and temperature, velocity and acceleration, and electricity and magnetism. In the back of the book are answers to the problems, logarithm and antilogarithm tables, and an index.

Definitions and Formulæ: Automobile Engineering

By H. Kerr Thomas, M.I.Mech.E., M.I.A.E., and Staton Abbey, A.F.Inst.E.

London: SIR ISAAC PITMAN AND SONS LTD., Parker Street, Kingsway, W.C.2. 1953. 4¼ × 5½. 28 pp. Price 1s.

The series of booklets on engineering subjects published for many years by Sir Isaac Pitman and Sons Ltd. is so well known that a detailed description here would be superfluous. The second edition of the one dealing with automobile engineering contains a great deal of information of interest to students. Some of it may also be of use to practising engineers for reference purposes.

The first section gives the formulæ used in thermodynamics, the second covers horse power calculations and the third deals with estimation of gas velocity past poppet valves, piston velocity and acceleration, and many other formulæ necessary for determining the performance of engine mechanisms. In section II friction clutches, shafts and axles are dealt with, section III is on brakes and section IV on gearboxes. The remainder of the work covers frames, springs, engine performance and testing, steering gear, cooling, fuels and combustion, and ignition systems.

The Motor Manual

By the Staff of "The Motor."

London: TEMPLE PRESS LTD., Bowling Green Lane, E.C.1. 1954. 4¼ × 7¼. 298 pp. Price 6s.

The Motor Manual, which is now published in its 35th edition, is written for the knowledgeable type of motorist who takes an interest in the vehicle he drives. It is a useful book for those who wish to acquire sufficient understanding of the mechanism of their car to be able to drive it well, and take the necessary steps to maintain it in good order.

This new edition well maintains the reputation established by its predecessors. It explains simply and clearly the working principles of the modern car. In addition, it deals with such recent developments as disc brakes, hydrodynamic drives and power steering. The work includes a chapter on caravanning and another on the law as applied to the motorist.

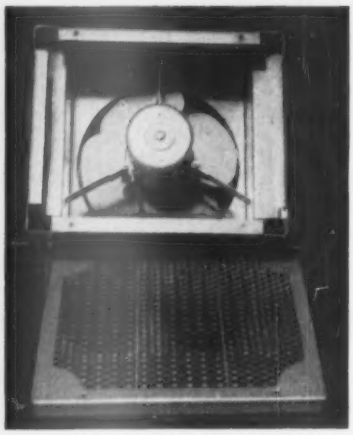
HEATERS

A Review of Recently Introduced Units

HEATING equipment has now become an integral part of vehicle design, and there are few buses and coaches that do not incorporate some method of raising the internal temperature and demisting the windscreen. In fact, the situation has been reached where the customer before hiring enquires of the coach operator if his coaches are fitted with heaters. Similarly, even in this country, heaters have almost come to be regarded as essential in private cars.

It is of interest to trace the course of development that has been followed in recent years. Initially, the view taken was that hitherto we had been accustomed to driving with windows closed in cold weather, so that the most economical way of providing the necessary warmth inside the vehicle was to install a recirculator type of unit. However, apart from the unpleasantness of this arrangement from the hygienic point of view, there still remained the problem of adequate demisting of the glass. With a recirculater type of installation, the air inside the car becomes increasingly laden with moisture as the occupants breath out more and more water vapour.

Then, to solve this problem it was, of course, necessary to employ fresh air type heaters. By using these units, it is possible to pass fresh air from the exterior of the car directly on to the windscreen and so to ensure rapid demisting of those areas of the glass that are most important from the point of view of visibility. Moreover, the dilution of the moisture laden air in the vehicle reduces the tendency for the side and rear lights to become misted over.

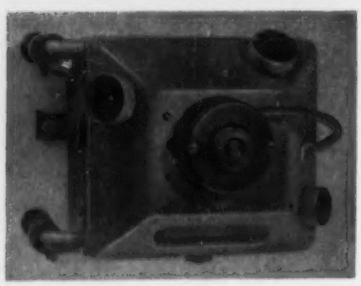


Smith's 8 kW heater

Until recently, almost all the units available in this country have been of the type that are supplied with heat from the engine coolant system. Some begin to operate soon after the engine has been started, but others are fairly slow in coming into effect and are not of much use to drivers who habitually travel short journeys. The best results, of course, are obtained when the temperature of the water circulated through the heater is raised quickly by virtue of the fact that a thermostat is incorporated in the engine coolant system. Nevertheless, there is a limit to the amount of heat that can be taken from the engine coolant and there is a demand, particularly in very cold countries, for fuel burning units. These units are most attractive for passenger transport vehicles because of the great output required to heat the large space involved and also to offset losses due to opening the doors to allow passengers to get on or off.

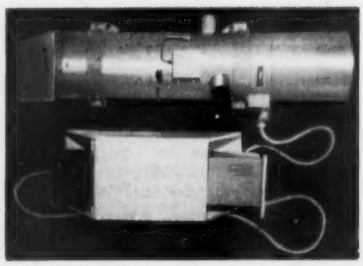
There are now several types of fuel burning heaters manufactured in this country and the number of water heated models available is constantly being increased. The efficiency of water heated units has improved, and many are more than satisfactory for private cars, and even for passenger service vehicles for certain types of operation. All the latest designs of heaters were displayed at the Com-

This heater is the model G, 2½ kW unit offered by Delaney Gallay Ltd.

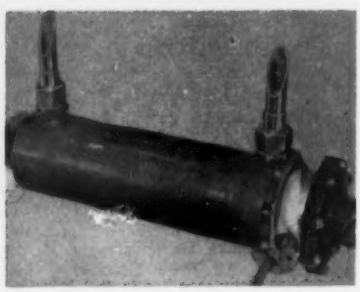


Key-Leather Co. Ltd. make this KL 414 heater for taxi cabs. The heat is taken from the engine coolant

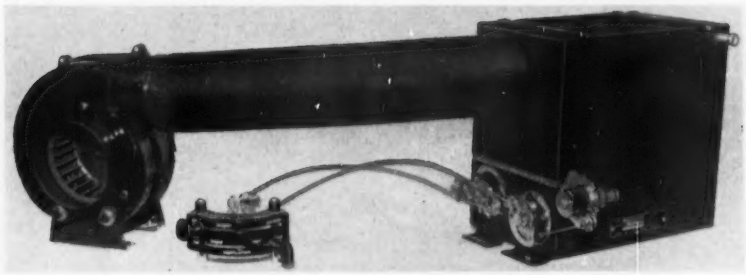
Clayton Dewandre 3½ kW heater assembly



The 50 ASM, oil burning air heater manufactured by S. Smith and Sons Ltd.



In this unit, made by Clayton Dewandre Co. Ltd., the heat source is a water jacket round the engine exhaust



The 3½ kW heater and control assembly made by S. Smith and Sons Ltd.

mercial Vehicle and Motor Shows at Earls Court this year, so in reviewing them it is hardly possible to do better than to comment on the exhibits that appeared at those Shows.

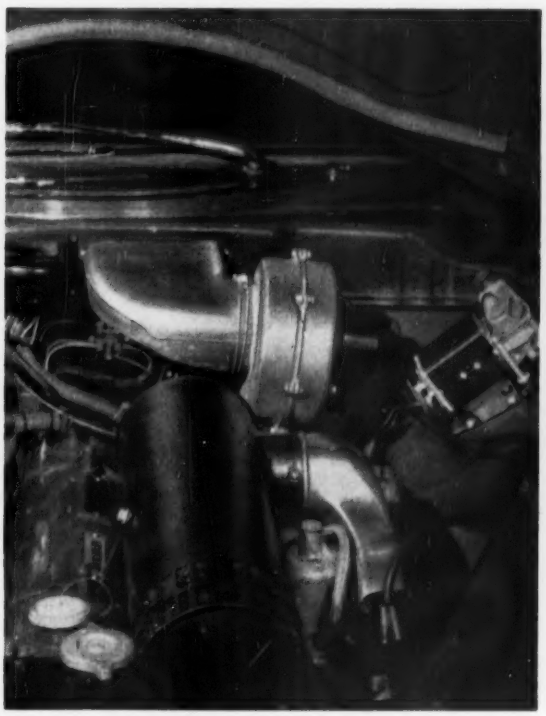
There are many examples of heaters for the smaller commercial vehicles: Delaney Gallay Ltd., Key-Leather Co. Ltd., S. Smith and Sons Ltd., and Clayton Dewandre Co. Ltd. all offer examples of these small units. This year Delaney Gallay have introduced two new units, the S and the G models. The S model has an equivalent output of 1¾ kW and has a speed control for the fan motor. It has adjustable outlet flaps for regulating the flow of hot air to the vehicle and to the demisting outlet. The G model is a 2¼ kW unit and can be supplied for building into the vehicle during erection, and is recommended for use in conjunction with a fresh air duct. It can also be supplied in a complete casing for fitment to existing vehicles.

Key-Leather Co. Ltd. showed a range of heaters, large and small. At the lower end of the range there is the KL 54 Mark II, for fitment to the new Thames 5 cwt van. This is fitted with a reversible motor with a speed control switch. There is also the Monitor unit for other light vans which provide about 1·65 kW of heat. As before, a reversible fan-motor is fitted, allowing a choice of demisting with or without interior heating, or heating only. A new unit is the taxi heater, type 414. This provides heated fresh air for the driver and also for the passengers' compartment. This equipment has received Scotland Yard's approval. Another new unit is the type 385, underseat heater for buses or coaches. Measuring 10½ in by 10½ in by 8¾ in, it has its own fan giving an airflow of 182 ft³/min and a heat output of 16,200 B.Th.U/hr. or 4·75 kW, at a temperature difference of 120 deg F.

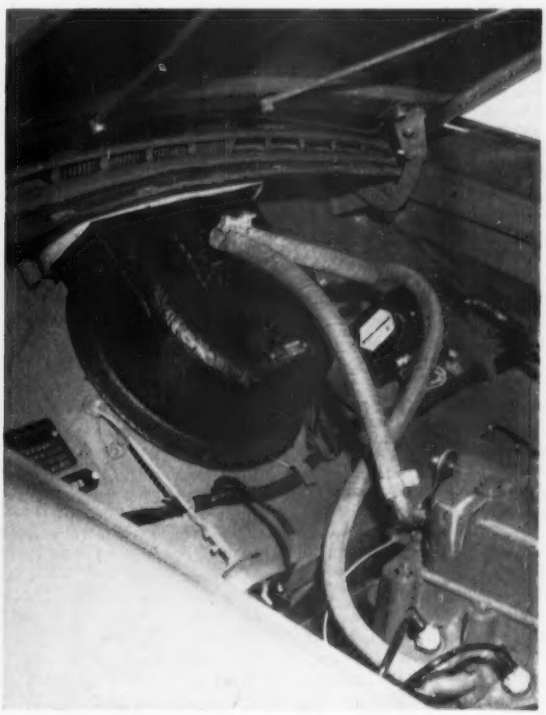
The Clayton Dewandre range of heating units for buses and coaches is already well known. To date, the heating element has always been formed from Clayton-Still wire wound tubing. An innovation this year is the introduction of the GHD 3·5 heater, which utilizes a monobloc heating element, presumably to reduce overall size. Other new developments of this firm are directed at improving the heat input to their heater units. The first concerns the over-cooling which often takes place on underfloor engines due to their exposed position and the inaccessibility of the radiator. In order to reduce this, shutters are fitted to the radiator, and are controlled by a cylinder actuated either by air pressure or vacuum from the braking system. The control of the operating cylinder is by means of a bi-metal operated valve. A pressure reducing valve is included when air pressure actuation is adopted. The system operates on a differential pressure of only 10-12 lb/in².

Another development by this manufacturer is an exhaust, water heater to boost the available heat from the engine cooling system and so increase the temperature of the water supply to the heaters. This unit, when mounted in a diesel engine installation, is capable of contributing 17,000 B.Th.U/hr.

S. Smith and Sons Ltd. public service vehicle heaters incorporate centrifugal blowers, making them particularly suitable for heating systems with distribution ducting. To

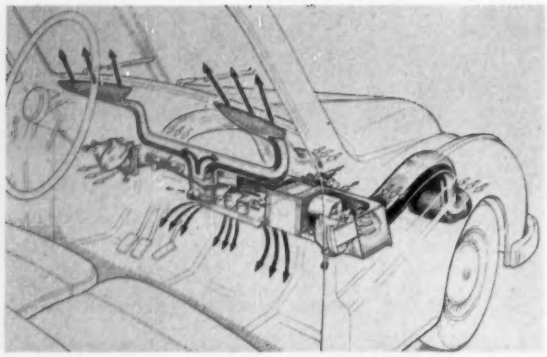


In the Wolseley Six-Ninety air is supplied to the heater through a scuttle ventilator



Only part of the full width, scuttle air intake of the Nash Metropolitan is used to supply air to the heater

The interior of the Wolseley Six-Ninety, showing how the demister units are served by two pipes from the central box installed under the dash



In the B.M.W. 501, air is supplied to the heater through the duct on the right-hand side and air for ventilation only enters through the left-hand one

supplement this range there is now a new series of underseat heaters, incorporating propeller type fans. These fans are capable of displacing large quantities of air for a very small input of electrical current. The new heaters are made to give two nominal outputs, 8 kW and 5 kW equivalent electrical energy. They are also suitable for special applications, such as canopy mounting on double deck vehicles, and may be used with fresh air intakes or as recirculators.

There is also a range of heaters that has been developed for heating the cabs of transport vehicles. They have nominal capacities of 3 kW and 3¼ kW. The units incorporate a high efficiency fan to provide adequate demisting and defrosting of the deep windscreens of commercial vehicles and are readily adaptable to meet a variety of installation conditions.

Another line of heater development merits serious consideration. It is in the field of fuel burning units. There are cases where a source of heat may not be available, as in railcars, boats, and in some workshops or buildings. Alternatively, there are cases where the output of heat from the vehicle engine cooling system is insufficient, either by reason of the volume of space to be heated or because of extremely low external ambient temperatures. This is where the fuel burning type of heater is needed. Both Key-Leather Co. Ltd. and S. Smith and Sons Ltd. manufacture units of this type. The KL 10,000 has already been described in the March 1954 issue of *Automobile Engineer*. It burns gas, oil or paraffin and, as the name suggests, is capable of producing 10,000 B.Th.U/hr. This firm is contemplating manufacture shortly in this country of a 75,000 B.Th.U/hr heater, but the unit was not on view at their stand.

The Smiths' 50 ASM unit has undergone re-design since the previous Commercial Vehicle Show. This re-design has been carried out for three reasons. Firstly, to improve starting characteristics at temperatures down to −65 deg F, as experienced in the export market, notably in America and Canada. Another is to overcome starting difficulties due to voltage variation of the battery from the discharged to the on charge conditions. The third is to incorporate an improvement in fan design whereby airflow is increased by 25 per cent. The unit is capable of an output of 50,000 B.Th.U/hr. Air is drawn through a heat exchanger by a fan and distributed as required in the space to be heated.

Fuel is fed to the combustion chamber by a positive displacement type fuel pump. A motor driven, centrifugal air-impellor provides air for combustion, and the fuel is supplied in a finely divided spray by means of a rotating disc type fuel slinger, and is thoroughly mixed with the air. The slinger is driven at 3,500 r.p.m. by the motor that also drives the combustion air-impellor. Ignition is effected initially by a glow plug, which is cut out of operation once the system has started.

Products of combustion are passed through the stainless steel heat exchanger. The pressure of the heated air outside the exchanger is always higher than the pressure of the combustion air inside. Thus, should a fracture occur in the exchanger, the heated air is not contaminated by the products of combustion. The system is fully automatic and is protected by safety devices.

At the Motor Show, the Key-Leather Co. Ltd. exhibited a basic range of vehicle heaters, with specialized versions for fitment to specific vehicles. One of these units, the type 54, has an output of 2 kW. This equipment has been adapted for fitting to the latest Ford Anglia and Prefect, the M.G. model TF, and the Triumph TR2. In the case of the M.G., the heater is fitted under the scuttle; it is inset into the baffle board and only protrudes ¼ in. A windscreen demisting fishtail is provided.

Clayton Dewandre Co. Ltd. showed a new 3½ kW heater unit utilizing a monobloc type of matrix in place of the Still tube design, on which this company's products hitherto have mainly been based. The equipment incorporates a centrifugal blower, which is mounted on the heat exchanger but, if necessary, can be installed remote from it and connected by flexible hose. A hot air distribution box is provided; it has flap valves to control the air flow to the different parts of the car.

S. Smith and Sons Ltd. had their standard 3½ kW heater on show; this has a centrifugal blower with all the heater controls embodied in the heat exchanger unit and remotely operated by means of push-pull flexible cables. The controls include a water shut-off valve for conversion of the installation into a fresh air ventilation unit in hot weather.

Installation arrangements are so numerous and varied that a whole book could be written on the subject. However, in private cars where the scope is perhaps more restricted than in commercial vehicles, the installations adopted tend to follow fairly well defined lines. Some examples of these layouts are shown in the accompanying illustrations.

One problem that has to be faced is the prevention of transmission of undue noise from the fan and its motor into the car. From this point of view, perhaps the best arrangement is to mount the blower forward of the engine instead of on the heater unit. This arrangement also is an advantage when there is not much space available adjacent to the heater, on the dash. A disadvantage is that the long length of ducting, which is essentially of fairly large diameter, may prevent ready access to the engine compartment. However, many manufacturers employ this ducting arrangement, even when the blower is mounted on the heater or directly on the dash.

An ingenious ducting layout to avoid obstruction in the engine compartment has been adopted on the latest Austin models. A pressed steel duct is employed and it is attached to the under-side of the bonnet lid. Therefore, when the lid is lifted, so also is the duct.

Another method of combating noise is shown in the illustration of the B.M.W. 501 installation. In this, a rubber mounted, ducted fan unit, together with the heater, is totally enclosed in an air distribution box.

DRIP-FEED GAS CARBURIZING

The Wild-Barfield "Carbodrip" System for Case-hardening Ferrous Alloys

GASEOUS cementation has become well established in industry as it makes possible a more precise metallurgical control, is cleaner in operation and is more economical than the earlier pack technique employed for case hardening. The process is accelerated by the application of the diffusion principle. Instead of the carburizing being carried out slowly at a relatively low temperature in order to prevent the formation of hypereutectoid, cementation is effected more rapidly at a higher temperature and the hypereutectoid constituent so formed is diffused to produce a final case of eutectoid composition.

The atmospheres commonly used for gaseous cementation are produced with the object of obtaining a reaction mixture containing carbon - monoxide, methane, and hydrogen in suitable proportions. Such deleterious constituents as carbon-dioxide, oxygen and water vapour are either completely eliminated or at least reduced to a minimum. In Britain, towns' gas is treated in a separate generator and, commonly, enrichment of the gas by topping up with a hydrocarbon is necessary. Piped methane may be employed in countries such as the U.S.A. and Italy where natural gas is available. Whichever is used, the gas is passed either through a burner or a column of catalyst material at high temperature and is thus partially burned, usually under endothermic conditions, to produce a carrier gas. To raise this gas to a strength suitable for carburizing purposes, a hydrocarbon gas such as propane or butane must be added. This technique is relatively expensive to operate and, since the added hydrocarbon must be broken down to methane to be effective in cementation processes, is liable to produce an undesirable quantity of soot.

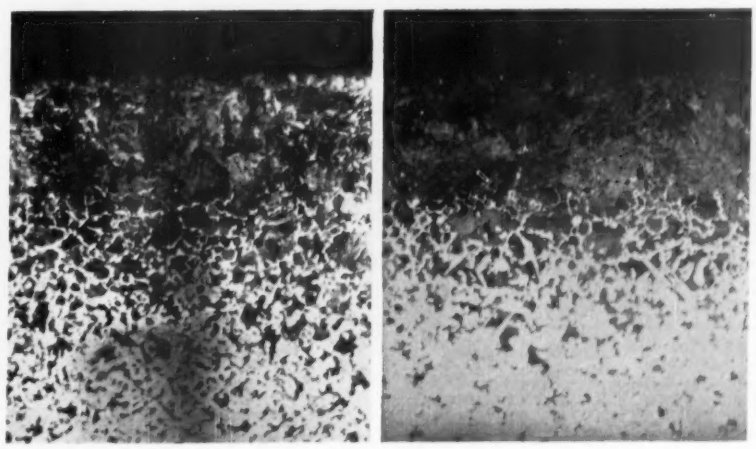
A development of this process, the Wild-Barfield "P.T.G." (Prepared Towns' Gas) method, differs in that the raw towns' gas is not burned during preparation and thus the valuable active constituents, methane and carbon monoxide, are conserved. Organic sulphur compounds are first abstracted and then the de-carburizing constituents, carbon dioxide, oxygen and water vapour, are removed without decomposition of the methane by passing the gas over a special catalyst at an elevated temperature. The resulting gas will effectively carburize steel without the addition of any supplementary hydrocarbons. From the analyses of a typical towns' gas before and after preparation, as given in Table I, the effect of the catalyst will be apparent. Apart from the removal of carbon dioxide and oxygen, and the reduction of unsaturated hydrocarbons, the gas remains substantially unchanged. This method has been widely used both in this country and abroad for twelve years.

TABLE I. ANALYSES OF RAW TOWNS' GAS, "P.T.G." ATMOSPHERE AND "CARBODRIP" ATMOSPHERE

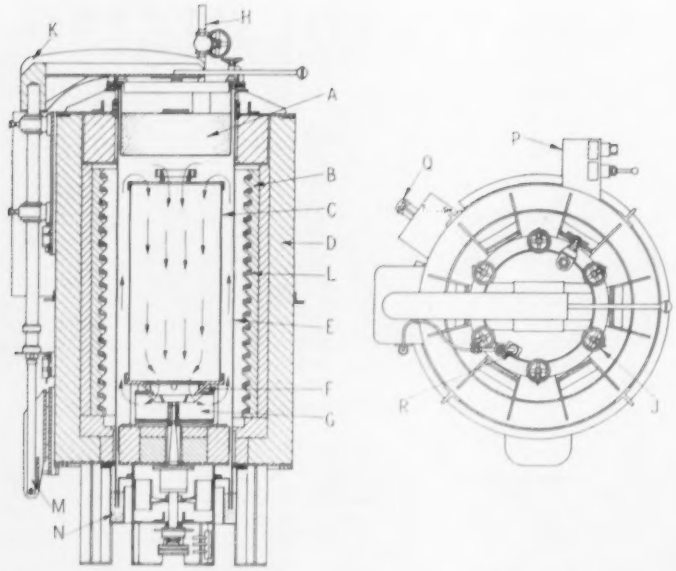
Constituent	Raw towns' Gas per cent	"P.T.G." Atmosphere per cent	"Carbodrip" Atmosphere per cent
Carbon dioxide	3·3	0·0—0·2	0·0—0·3
Oxygen	0·6	0·0—0·1	0·0—0·2
Unsaturated hydrocarbons	2·1	0·4—0·6	0·2—0·6
Carbon monoxide	16·4	20·2	20·0—25·0
Methane	24·0	23·6	20·0—25·0
Hydrogen	49·5	51·2	58·0—48·0
Nitrogen	4·1	Bal.	—

As an alternative to towns' or natural gas, carburizing atmospheres can be derived from organic liquids, such as mixtures of alcohols and hydrocarbons, which are fed directly into the furnace by the drip method. The liquid is pyrolyzed and circulated throughout the charge of work by means of a fan to yield an atmosphere having an effective carburizing potential. While this method has a misleading appearance of simplicity, careful control of conditions is necessary to ensure practical and repeatable results. For example, some of the liquid mixtures used were unduly sensitive to flow rate or were over-rich in their constituents and were liable to produce heavy sooting, with a consequent stopping-off effect on the work, unless an extremely careful control was exercised.

With these considerations in mind, and in view of the economies and advantages offered by the drip-feed system, the Company undertook a comprehensive programme of research to evolve a liquid mixture that would pyrolyze to produce a carburizing gas of a composition similar to Prepared Towns' Gas (P.T.G.) without decomposition to carbon occurring during the reaction cycle. Providing such a mixture could be produced and its derivative atmosphere was sufficiently close constitutionally to that of "P.T.G.", it was assumed that carburization could be effected at the same rate and that diffusion periods of the same order would be required to yield cases of eutectoid composition. Thus the conditions of carburizing, which had long been standardized for



En 32 steel carburized for 2.75 hr total time at 925 deg C in (left) "Carbodrip" and (right) "P.T.G." atmospheres. Etched 2 per cent Picral. Magnification × 50



A Retort plug door — B Element bricks — C Baffle — D Insulation
E Retort — F Throat — G Fan — H Burn-off tube
J Retort door clamps — K Door lifting arm — L Elements — M Hydraulic jack
N Retort seal — P Hydraulic control panel — Q Thermocouple — R "Carbodrip" entry tube

Section of fixed-retort gas carburizing furnace arranged for "Carbodrip" atmosphere

"P.T.G.", would remain unaltered and the accumulated experience, including reliable time-penetration data for a wide range of steels, would be available for immediate use with the new technique. Essential prerequisites of such a liquid mixture, dictated by experience with gas carburizing mixtures, were as follows:

1. The constituents should be readily available and relatively low in cost.
2. The resulting atmosphere should virtually be free from decarburizing gases.
3. Deleterious sulphur compounds should not be present.
4. Undue sooting should not occur during pyrolysis.
5. The rate of feed should not be critical and satisfactory metallurgical results should be obtainable over a reasonably wide drip rate.

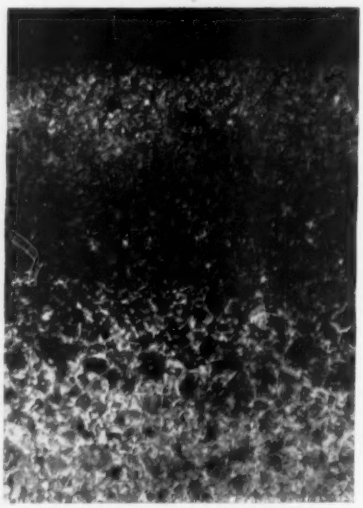
A liquid mixture fulfilling the postulated conditions was eventually discovered early this year and is the subject of a British Patent Application No. 2830/54. The mixture is known by the trade name of "Carbodrip" and has been extensively tested, first in a pilot plant and subsequently in a full-scale industrial installation. From Table I it will be noted that the gas analysis figures for the pyrolyzed "Carbodrip" are closely similar to those for "P.T.G." Total time (T) at the carburizing temperature is divided into an active carburization period (t), during which carbon is fed to the steel as rapidly as it can be absorbed, and a diffusion period (T−t) when the absorbed carbon is diffused into the steel. During the diffusion period, the drip feed is cut off, the retort outlet is closed, and the atmosphere allowed to remain static.

When preliminary tests had been concluded a selection of En steels were carburized in "Carbodrip" and "P.T.G." atmospheres at 925 deg C and at 950 deg C under identical conditions of total time (T) and diffusion ratio ($\frac{T}{t}$). The comparative results are recorded in Table II and photomicrographs of En 32 specimens carburized for a total time of 2·75 hr are shown. The drip-feed method can also be used for carbonitriding. Anhydrous ammonia to the requisite quantity may be fed directly to the furnace and independently of the "Carbodrip" liquid or, alternatively the drip-feed liquid may be specially mixed to contain the necessary nitrogenous liquid. Results obtained by this method are of a standard similar to those obtained with a carbonitriding atmosphere developed wholly outside the retort.

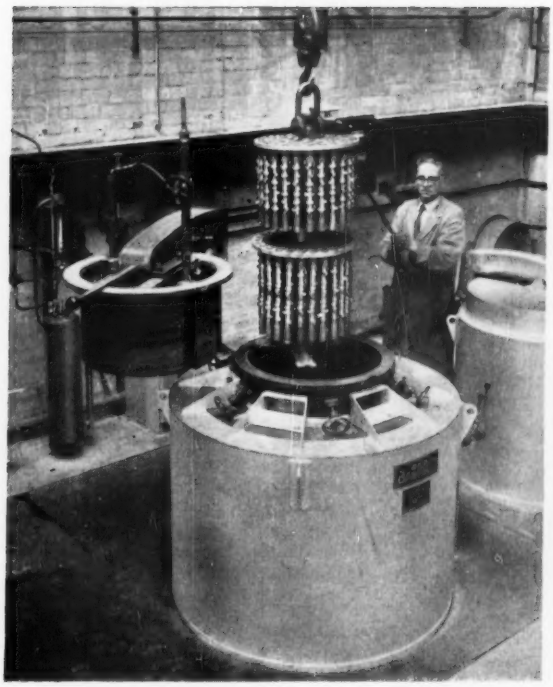
In general, the same furnaces as those used for orthodox gas carburizing may be employed for the drip-feed method. Exceptionally, those specially designed to take a withdrawable, heavyweight retort require a modified retort door to allow the introduction of the liquid to

TABLE II. COMPARATIVE CARBURIZING RESULTS WITH "CARBODRIP" AND "P.T.G." ATMOSPHERES

Steel	Temp deg C	Total Time hr	$\frac{T}{t}$ ratio	Atmosphere	Case Depth	
					Total in	Eutectoid in
En32	925	2·75	1·4	Carbodrip	0·039	0·023
				P.T.G.	0·040	0·022
En32	950	1·60	1·5	Carbodrip	0·041	0·023
				P.T.G.	0·040	0·022
En34	925	3·20	1·55	Carbodrip	0·042	0·026
				P.T.G.	0·040	0·025
En34	950	3·10	1·75	Carbodrip	0·050	0·032
				P.T.G.	0·050	0·032
En36	925	5·25	1·60	Carbodrip	0·050	0·037
				P.T.G.	0·050	0·036
En36	950	4·75	1·85	Carbodrip	0·060	0·045
				P.T.G.	0·060	0·044
En39	925	9·00	2·0	Carbodrip	0·065	0·045
				P.T.G.	0·062	0·045
En39	950	9·20	2·3	Carbodrip	0·072	0·056
				P.T.G.	0·070	0·055



En 32 steel carbonitrided by "Carbodrip" + 2·5 per cent NH_3 for 1·0 hr at 850 deg C and oil quenched. Total case depth 0.015in. Etched 2 per cent Nital. Magnification × 250



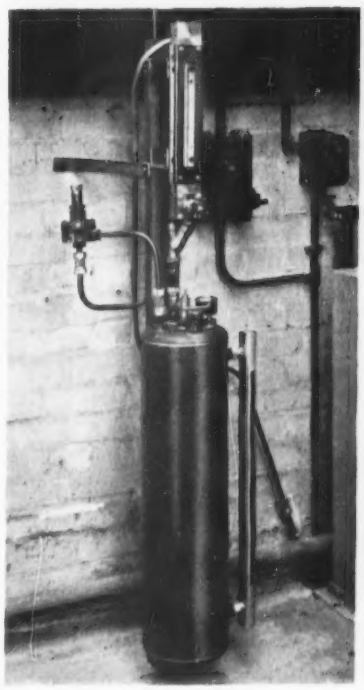
A batch of camshafts being charged into the furnace

the furnace instead of the usual gas entry at the bottom.

Furnaces are of standard vertical design and incorporate a liner having a positive, clamped seal at the top and a chrome ore seal at the bottom. The door is raised by means of a power-operated hydraulic ram and swung on a cantilever arm. To ensure the efficient gas circulation which is essential for drip-feed carburizing, a centrifugal fan located in the base and driven by an electric motor operates in conjunction with an inner baffle mounted coaxially on the throat casting.

At present four sizes of standard furnaces are available, with work space dimensions ranging from 10 in dia × 15 in deep to 24 in dia × 48 in deep. These are similar to furnaces currently used with "P.T.G." The Company consider the furnace with the 16 in dia × 30 in deep space is the smallest size to be operated economically with a gas preparation plant. With the drip-feed system, however, smaller carburizing furnaces are held to be economical owing to the substantially lower capital cost of the "Carbodrip" installation. Accordingly, a range of smaller furnaces is being designed to meet the requirements of smaller heat-treatment establishments for gas carburizing plant. Special sizes are produced to meet specific requirements.

To feed the "Carbodrip" liquid from the holding tank to the furnace only simple equipment is required. It will be appreciated that since the cost of the liquid is higher than that of towns' gas it is essential to keep consumption down to a minimum, to avoid waste, and to control the flow within fairly narrow limits. Hitherto, it has been customary to control drip rate by means of a metering pump and the only way the flow rate could be checked was by measuring the quantity of fluid delivered. On the "Carbodrip" system the liquid mixture is delivered to the furnace by air at a pressure of 5-10 lb/in^2, instead of by a pump, and an indicating flowmeter is provided. All that is needed is a reducing valve to lower the shop line pressure and a small water trap. If a works supply of compressed air is not available a very small portable compressor and a capacity vessel will suffice.



The "Carbodrip" feeding apparatus

The complete apparatus comprises a vessel holding approximately 10 gal of the liquid mixture. This vessel is fitted with a well-protected sight glass revealing the quantity of liquid contained, a pressure gauge, a safety valve and a filler cap. The admission of compressed air to the vessel forces the liquid up an internal pipe and through a filter, a fine-control needle valve, a flowmeter, and thence by a flexible pipe to a jet in the retort door. The whole installation is simple and has no moving parts.

Work carriers do not differ from those required when using the orthodox gas carburizing process. Preferably, they are designed to hold the maximum number of a particular component. Trays and baskets may be used for small components providing that consideration is given to the problem of local shielding of one component by another. As the atmosphere in the

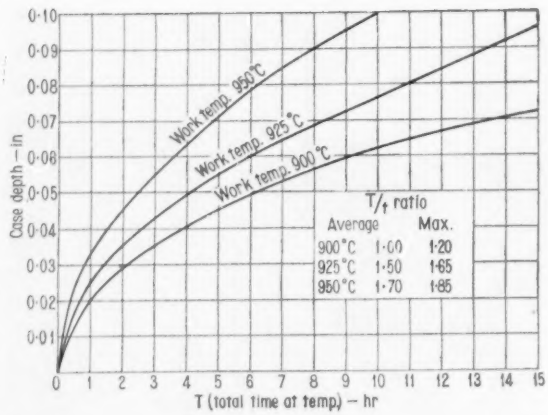
Gas carburizing installation, comprising furnace, drip-feed apparatus and cooling pit. Charging space 16 in dia × 30 in deep

retort is circulated by a powerful fan, this problem is reduced to a minimum. Carriers or baskets must be of high quality nickel-chromium alloy to ensure long life and minimum distortion.

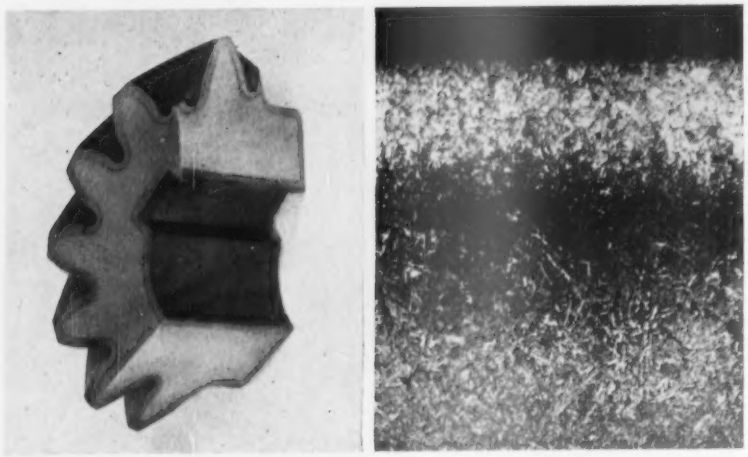
When the work has been carburized it is transferred to a cooling pit, located alongside the furnace, and allowed to cool slowly in a protective atmosphere. Commonly raw towns' gas is used for this purpose but any non-oxidizing atmosphere can be employed. If necessary, an atmosphere derived from "Carbodrip" liquid, either specially produced or tapped from a furnace, would meet the requirement. Some work necessarily will be directly quenched in oil or water and in such cases the carriers or baskets must be specially robust in construction and designed to ensure a rapid and uniform cooling of the charge in order to obtain consistent results.

While the metallurgical results of the "Carbodrip" process are virtually identical with those obtained by orthodox gas carburizing, the drip-feed method offers a number of advantages of some economic value. These may be summarized as:

1. The process is simple to operate and does not require laboratory supervision.
2. It is independent of a supply of raw towns' gas or natural gas and consequently not susceptible to variation in the chemical composition of those gases.
3. The "Carbodrip" liquid is completely free from the sulphur compounds which must, in some cases, be specially removed from towns' gas.
4. There is economy in floor space since the "Carbodrip" feeding equipment occupies only a space of 1 ft 6 in × 1 ft 6 in × 5 ft high.
5. For a given work programme, the drip-feed method requires a lower capital outlay than does the orthodox gas process.
6. Power costs are lower since it does not require the operation of a catalyst furnace.
7. Maintenance costs are extremely low as practically all that is necessary is to replenish the vessel holding the liquid.



Typical time-penetration curves at different temperatures for En 32 steel



Spiral-bevel pinion in En 36 steel sectioned to show case depth of 0·060 in. Carburized for 7·5 hr total time at 925 deg C, T/t ratio 1·6. Micrograph of specimen, etched 2 per cent Nital, magnified × 50

PISTON DESIGN

AN article entitled "Basic Features of Good Piston Design," by F. Jardine, has been published in *Automotive Industries*, May 1, 1954. In it, recommendations are given for the optimum pattern for an aluminium alloy piston. The merits are considered of a piston having a flexible skirt for conformability to cope with the different expansion rates of aluminium and cast iron. Rocking of the piston in the cylinder bore can be minimized by making the overall piston length 110 per cent of the cylinder diameter. Above the gudgeon pin axis, the length of the portion of the piston that is subjected to compression loads should be 50-60 per cent of the cylinder diameter. To avoid high bearing pressures at the top of the skirt, a minimum of 25 per cent of the thrust face length should be above the horizontal plane containing the gudgeon pin axis.

In high compression engines, the gudgeon pin should have a diameter of about 28 per cent of the cylinder bore and should be sufficiently rigid to prevent excessive deflections that might cause premature piston failure through fatigue. A chamber, cast or machined on the inner edges of the gudgeon pin bores, helps to ensure satisfactory stress distribution in the bosses. Ring land size is important for heat flow and rigidity; the top land is made wide to assist heat flow from the piston head and give added protection to the top ring from high flame temperature. High temperatures in the ring grooves may cause excessive groove wear and other troubles. The remaining ring lands may be made successively thinner, since the temperatures and pressures involved are lower. At room temperature, diametral clearances for ring lands are set at 0·008 in per inch of piston diameter for the top land and at 0·006 in per inch for the rest.

With flat crown pistons, a short ring belt may promote undesirable deflection of the crown and increased skirt deformation. Rigidity is obtainable with a short ring belt if the piston crown is convex or dome-shaped. Such a crown should not project far into the combustion chamber as, otherwise, the heat flow from combustion gases to piston is increased.

Piston crown thickness should be about 0·065 times the cylinder bore, while skirts are usually at least $\frac{1}{16}$ in thick. Increased skirt thickness makes for greater strength; greater flexibility is gained by incorporating horizontal or vertical slots. Cam contour machining or grinding of the skirt secures low clearance at room temperature for the thrust faces and suitable shoulder clearance at operating temperature. *M.I.R.A. Abstract No.* 6951.

LARGE QUANTITY PRODUCTION

Automation and its Implications for Management

DURING the past six or seven years much has been written about production developments in the British and American automobile industries, but there has been very little published, at least in this country, about Continental developments. Therefore the paper "*Automation—Implications for Management*," presented on behalf of Monsieur Pierre Bezier, Directeur des Methodes Méchaniques for the Renault organisation, to the recent European Management Conference organized by the British Institute of Management, should be of great interest to production engineers in the British automobile industry. The following notes give the substance of Monsieur Bezier's paper.

There are still wide differences in the means used for large scale production. In the United States of America nearly all the factories are equipped with specially developed machines of the transfer type with multiple heads for milling, drilling, tapping and spotfacing operations. A typical American machine of this type is shown in Fig. 1. It is a Footburt machine for machining Mercury cylinder blocks. In British and European factories, on the contrary, there is not the same uniformity of approach to the problems of large scale production. Some of these factories are using methods closely related to American practice. An example of this is shown in Fig. 2, which illustrates a transfer machine for Renault Frégate cylinder heads. Others use standard machines such as milling machines with manual or automatic controls, radial and sensitive drills and centre lathes. A good example of this type of production layout is illustrated in Fig. 3, which shows a line for machining Ferguson tractor gearboxes.

The selection of the means of production is governed by several considerations. Those having the greatest are: first, the time factor for getting manufacture started on the product; and second, the advantages and disadvantages of the different types of available equipment.

It is fairly easy to estimate the relative investment necessary for different solutions. This investment is, of course, made up mainly of the cost of the machines, the cost of installation, and the price of the buildings to house the machines. It is also possible to estimate reasonably accurately the differences in labour costs for the various proposed arrangements. Furthermore, it is reasonable to consider, without great risk of error, that other indirect expenses will hardly be affected by the choice of manufacturing equipment. That is, such expenses as cutting tools, lubricating oils, coolants and electrical current will be reasonably constant for a given volume of production, even though the methods differ.

On the other hand, it is much more difficult to determine certain other costs that must arise from use of the equipment. They include maintenance and repair charges and the value of work in progress, or contingency stocks, to be held against the possibility of a breakdown in production. However, approximations can be made from results obtained in the course of operating similar installations.

Manufacture of machines

The design, manufacture and bringing into operation of a group of special machines, may take on very different forms, according to the means available to the industry in the country under consideration. In the United States, more than 30 firms specialize in the manufacture of these special machines. Collectively they employ thousands of specialists, engineers, technicians, designers and skilled tool makers. Under these conditions a company wishing to obtain this type

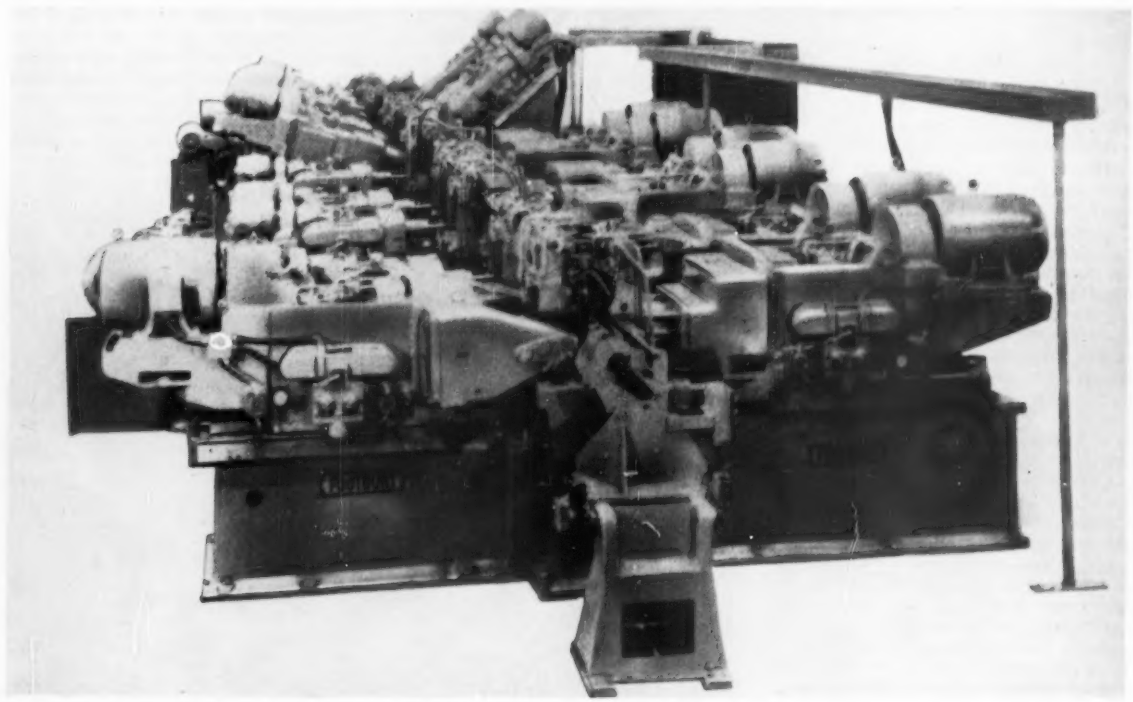


Fig. 1. Footburt transfer for Mercury cylinder heads

Fig. 2. Renault transfer machine for Frégate cylinder heads

of equipment has the opportunity of consulting several manufacturers, all willing to give the benefit of their experience and manufacturing facilities. Frequently, the shortness of time available for the installation of the new equipment makes it necessary to divide the work between several companies. In general, the specialist companies in the U.S.A. have good relations with each other, and the division of work does not injure the quality of the final product.

The purchase of special machines requires, first a very close liaison between the machine supplier and the machine user, because in the machine design, account must be taken of the buildings in which the machines will be installed, the methods of materials handling, automatic, semi-automatic or manual, which are to be used for the transport of the work, the arrangements for scrap disposal, and the distribution arrangements for services such as compressed air, cutting fluids and electric current. On this last point it is worth noting that some machines use a power of several hundreds of kilowatts. It may be necessary to install such machines near transformers in order to economize on large section electric cables. As heavy starting loads may produce a lowering of voltage in the electric system, it may be necessary to space the machines systematically, and to arrange that the power is fed to them through a special circuit in which the voltage is more or less independent of the demands on current.

It can also happen that the design of the product is modified during the designing or manufacture of the machine. In such a case, the machine tools will also have to be modified, but if they are nearing completion, it may be necessary to effect some compromise solution in order to reduce the loss in time or money that would be caused by a drastic modification. On the other hand, the machine tool specialist may ask for a modification in the component design in order to facilitate its manufacture and reduce the cost of the equipment.

The acquisition of all the machine tools necessary for a new manufacturing programme is only possible if a machine tool industry capable of satisfying a heavy demand within a reasonable delivery time is in existence. Such an industry can only exist if a sufficiently large group of customers is available so that a steady flow of orders can be maintained and regular and sufficient work be assured. These conditions obtain in the United States of America.

European factories generally have had to use both the American machine tool industry and the machine tool industry of their own countries. It has to be recognized, however, that in the absence of a common language, technical liaison with a supplier several thousands of miles away is often difficult and results in delays and useless expense. This is perhaps the reason why one British organization, Austin Motors Ltd., designed and constructed a section of its own specialized machines, an example is illustrated in Fig. 4, and obtained the balance from reputable British manufacturers.

Renault developments

In 1946 the Renault Corporation started to plan the machine equipment for the Renault 4CV. At that time it was impossible to go outside France for much equipment. In the first place, the foreign currency available was barely sufficient to cover the purchase of indispensable machines, large multi-spindle automatics, cam grinders, bevel gear shapers, etc., most of which were manufactured in the United States. At the same time the specialized machine tool industry in France had not the means to carry out the programme in the time available. It was, therefore, decided that all the special machines should be manufactured in the Renault tool room. Fortunately the Corporation had considerable experience of this kind of work.

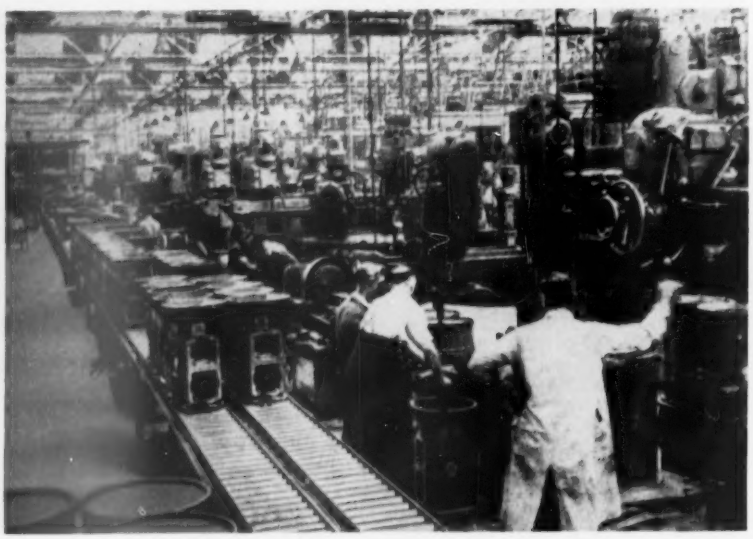


Fig. 3. Machining line for Ferguson tractor gearboxes

Between 1946 and 1954 the Renault Corporation designed, constructed and put into operation more than 600 special machines. They included more than 3,000 automatic machining heads and 535 are used in the manufacture of Renault vehicles. While necessity forced this policy on the Corporation in the first instance, it has been continued because it was found to have several important advantages. Whereas in other factories there are usually similar machine elements of different makes in use, in the Renault factory identical units are employed. This greatly simplifies maintenance and repair. The machine units are of three types, graded between 1·5 and 15 h.p., while the transfer machines are made up of standard blocks fitted with slides of two widths. Through making their own machines, Renault found that liaison between the product design office and the machine tool section was greatly simplified.

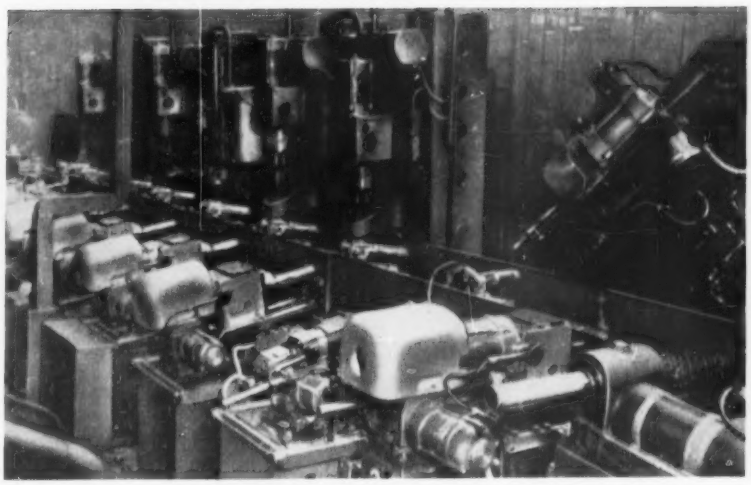


Fig. 4. Austin transfer machine for A.30 gearboxes

Machine utilization

If a preliminary cost investigation justifies the use of equipment of high capital cost, those who have to use the equipment must ensure the maximum utilization to reduce the overhead charges for operation and maintenance. Apart from accidental and fortuitous causes, there are two principal factors that reduce the output from a special machine. They are, (a) the time taken for loading and unloading the machine, and (b) the time necessary to replace worn tools.

When automatic systems bring the workpiece to the point of machining and fix it before the machine units come into action, the loading time is practically nil. For this to be possible the workpiece must present machined surfaces that permit a rapid and precise location. This is particularly the case with cylinder blocks, cylinder heads, certain crankshafts and some gearbox castings. It is then necessary for the mechanisms for moving and clamping the work to be specially designed. This can be done only at the expense of standardization, with all that this involves in increasing manufacturing costs, increasing delay in bringing the equipment into service and reducing the possibilities of recovering the cost. A transfer machine that locates from machined surfaces on the workpiece is illustrated in Fig. 5.

Fig. 5. Baush transfer machine for V.8 cylinder blocks

If, on the other hand, the workpiece is of irregular shape, it must be clamped on a fixture which itself presents reference faces for location and fixing in the machine. A Renault fixture used for machining a 4 CV exhaust manifold is illustrated in Fig. 6. This method requires a conveyor for bringing the empty fixtures back from the unloading to the loading station. If the machining operations are fairly short, the speed of the machine depends upon the time of loading and unloading the workpiece. In order to reduce these idle times, certain American manufacturers employ hydraulically- or pneumatically - operated spanners. Against these inconveniences, the use of special work fixtures has one capital advantage; it allows standardization of the elements in the machine line. That is why the Renault Corporation uses this method everywhere, even for workpieces of regular shape.

Certain very important machines carry several hundred tools. If the need of production calls for very high feeds or speeds, or if the workpieces are in a tough metal, the frequency of tool changes can be high enough to appreciably reduce the effective output. The use of tungsten carbide has increased the life of

Fig. 6. Transfer machine fixture for Renault 4CV exhaust manifolds

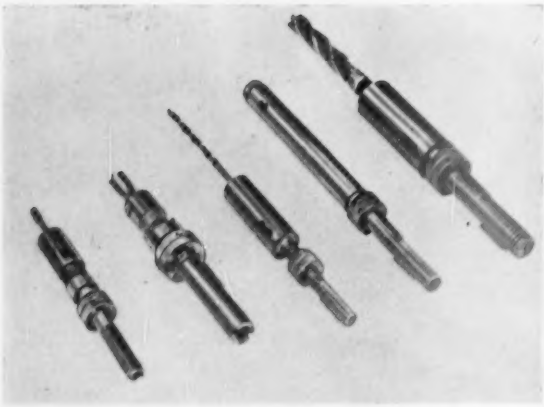


Fig. 7. Renault tool holders with adjustable shanks

milling cutters and reamers, but the use of carbide tipped drills has not yet emerged from the experimental stage. However, most of the tools found on special machines are of high speed steel. For machining cast iron they usually work dry; for cutting steel it is essential to cool the tool and soluble oil is the usual coolant. High pressure tool tip lubrication (Hi-jet type) is difficult to apply to rotating tools. The same may be said of refrigeration by CO_2. Renault have used oil mist lubrication of taps and reamers for shallow holes. This has made it possible to ream more than 2,000 pieces in 60 ton/in^2 between regrinds, a considerable improvement.

Machine speeds

In fixing speeds for a multi-tool machine, the Renault practice is to employ the maximum speed for the longest operation. For the other tools the practice is to use the minimum speed compatible with the rate at which the machine works. To reduce the time necessary for changing tools, they are mounted on extensions, the length of which is adjusted in advance, see Fig. 7. This length is standardized for all tools of the same diameter in such a manner that there is complete interchangeability between all the machines in the factory. To facilitate tool setting, the setters have racks, see Fig. 8, and appropriate setting equipment, see Fig. 9.

Since the idle time while tools are being changed is a direct function of the machine speed, while the expense of grinding (labour, tool wear, wheel wear, etc.) is an inverse function, it can be seen that the speed corresponding to the minimum of the sum of these two functions can be determined only by long statistical study. Furthermore, the inevitable variations in the quality of the tools and the machinability of the work material rarely makes it possible to determine this value within 25 per cent. Nevertheless, an estimation even of this order of inaccuracy is much better than a mere disregard of this factor.

However, it is possible to classify all the tools on any one machine into several groups. Each group is then given a frequency of change. The basic frequency for any one machine is that for the weakest group; all the other frequencies are multiples of the basic figure. For most important machines it is the Renault practice to have a counter that records machine cycles near the setter's post. This device is not so much used to define exactly the optimum wear of the tools, but rather to warn the setter of the nature of the tools that will have to be replaced. In this way hold-ups due to lack of replacement tools are avoided. This method is a less complete answer than the Cross "Toolometer," but it is sufficient for the conditions of work in the Renault factory.

Renault experience in the use of special machines has made it possible to lay down certain simple rules which can reduce the consequences of unforeseen breakdowns. To begin with, great importance is attached to the standardization of equipment, since this allows the maintenance engineers to be conversant with all the machine elements. As a result, faults can be diagnosed rapidly and the repair or replacement of a defective part is simplified. This advantage is considered to be of such importance that standardization of equipment parts has been carried to the greatest possible lengths.

The results of standardization can be shown by a few figures. One department annually manufactures mechanical components for 120,000 4CV cars on 1,420 machine tools. There are 87 maintenance engineers, 66 of whom repair the 1,200 standard machine tools, while the other 21 suffice for the maintenance of 200 special machines, which in terms of output are of equal importance to the other 1,200. Therefore the standardization of machine elements, which applies only to the special machines, has made possible a 70 per cent reduction in the maintenance staff.

It is important to select equipment that is designed to withstand several years of intensive operation. While organizations lacking adequate financial resources often tend to select the cheapest machines, certain American firms systematically purchase equipment a size larger than is strictly necessary. This goes far towards assuring that the equipment will function for several years without interruption. It is also desirable that equipment shall have some degree of flexibility. Therefore, it is advisable to avoid units with a short stroke. Renault practice is to consider 12 in travel to be the minimum advisable.

While many machine builders continue to use hydraulic controls, Renault prefer electro-mechanical systems. The principal reason for this preference is that the electro-mechanical systems can be applied with equal facility to drilling, tapping or milling cycles. Therefore, if a piece of equipment is taken out of service because a particular model has been superseded, it can be applied to some other kind of work.

It is also thought that electro-mechanical systems simplify the detection and repair of breakdowns. Furthermore, it is considered that mechanical movements are more constant than hydraulic movements if a screw rather than a cam is used.

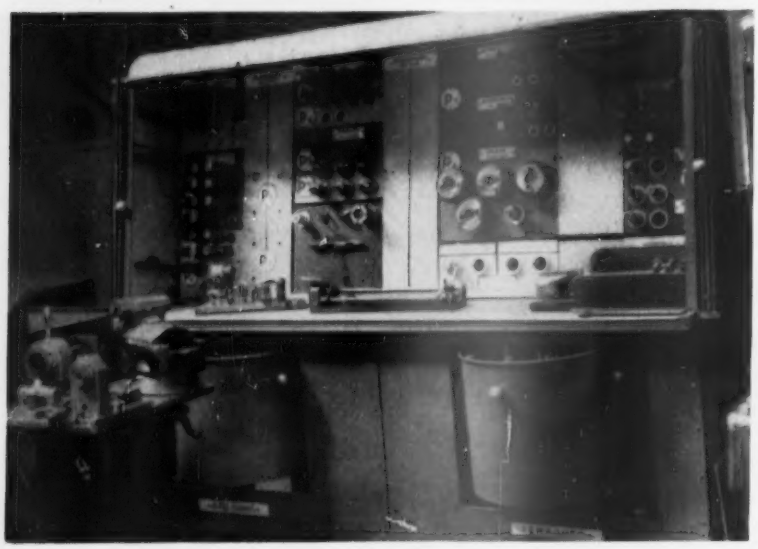


Fig. 8. Renault tool racks

Finally, the functioning of the machine is independent of the workshop temperature, nor is there the periodical cleaning of pipes that is essential with hydraulic systems.

Although the desirability of preventive maintenance is fully recognized, the intensive employment of the equipment in the Renault factory makes this impossible. All that is done in this respect is that electricians make periodical inspections of the relays and wiring in order to clean contacts and, when necessary, make replacements before failure occurs. Automatic machine lubrication is employed, and a daily inspection of the pumps is all that is necessary.

Component stocks

Stocks of components built up between operations or at the end of a line are obviously a source of expense since they immobilize capital. The interest on this capital may be regarded as a premium paid to insure against the consequences of breakdown. In general, the Renault practice is to hold a stock equivalent to two days' output at the end of the manufacturing line. If the assembly of the vehicle takes place near the component manufacturing line, a stock of one or two days' production of completed components is built up, but when assembly takes place in another factory, the stock represents from three to five days' output.

Within the machining line itself, buffer stocks between ordinary machines are held to a minimum, and it is hoped to reduce them to zero. Nevertheless, as long as there is a difference between times for successive operations, some stock must be built up between a fast and a slow machine. For a manufacturing line composed of several transfer machines of great length, it is considered essential to stock workpieces at intermediate positions in such quantities as will provide for stoppages of from thirty minutes to four hours, depending upon the importance of the machine, the fragility of the tools, or the difficulty of the work carried out on the machine.

Personnel

Originally it was thought that the personnel for operating expensive and complicated machines would need extensive technical training, and that it would be necessary to have a high proportion of supervising and maintenance personnel. These two fears have proved to be without foundation. In fact, seven years' experience shows that the proportion of indirect personnel is lower in the 4CV manufacturing department, the most highly mechanized, than in any of the other Renault shops. There is a total staff of 2,800 people with the following percentages not directly engaged on production:—

Engineers	0·3
Shop managers	0·5
Foremen	2·1
Chargehands	2·5
Indirect labour	18·0
Maintenance engineers	3·7
Electricians	1·5

Fig. 9. Renault equipment for precise adjustment of tool length

A shop manager, for example is responsible for the daily production of 580 sets of the following parts:—cylind r blocks and heads; oil pumps; water pumps; connecting rods and caps; pistons; sleeves; and various other parts such as axles. This shop has 320 operatives, controlled by nine foremen and ten chargehands, roughly one supervisor to 20 workers. There are 41 setters.

ENGINE DESIGN

IN an article entitled "A Comparison of Modern Engine Design," by L. W. Thompson, in the June 1954 issue of *Inst. Automotive and Aeronautical Engineers Journal*, a survey is made of modern developments in engine design, with a brief discussion of the gas turbine. Increased compression ratios are considered an important factor in obtaining higher efficiency, and can be made possible by improved quality fuels and/or suitable engine design measures. Advantages of high compression engines so far as performance and economy are concerned are shown by tests carried out with different models of Cadillac cars. To accommodate the large overhead valves required for high compression, high volumetric efficiency engines, stroke:bore ratios of less than unity are required. The Chrysler hemispherical chamber is claimed to possess advantages in high volumetric and thermal efficiency, reduced power loss due to physical and thermal restrictions to gas flow caused by carbon accumulation, reduced detonation, pre-ignition, and heat loss to the coolant.

Advantages of valve rotation are discussed, and representative types of valve rotator described. Cast-in austenitic iron piston ring groove inserts have been successful in reducing top groove wear in aluminium alloy pistons. However, correct bonding of the materials is necessary to reduce piston crown temperatures.

The Buick V8 engine is described. A 90 deg, V8 design was chosen for compactness, lightness and rigidity. The low stroke:bore ratio and vertical in-line valves give minimum engine width and low inertia loads. The inverted-V combustion chamber, with piston crown closely conforming to this shape, promotes high turbulence and minimizes the distance of flame travel.

General features of the 1953, as compared with 1952, engines include slightly higher rotational speeds for maximum power and lower engine speeds for a given road speed. Compression ratios have been increased. Cam-ground, tin plated aluminium pistons with fully floating gudgeon pins are predominantly used, and there is a trend towards the employment of fewer scraper rings. Chromium plated top compression rings are widely fitted.

The Volkswagen engine is discussed, with special reference to the thermostatically controlled air cooling employed. Advantages of open, swirl, and pre-combustion type diesel combustion chambers and of air- and liquid-cooled diesel engines are compared. Swiss and British examples of air-cooled diesel engines, and the combustion chamber and gas flow in the General Motors "51" high-speed two-stroke diesel engine, are described. Advantages and disadvantages of gas turbine power plants are briefly outlined. *M.I.R.A. Abstract No.* 6949.

CAB DESIGN

The Quest for Light Weight in Goods Vehicles Now Extends to Cabs

FROM an examination of the structure and design of the cabs of goods vehicles recently introduced it becomes apparent that cab designers are having to reconcile in their designs a number of partly contradictory requirements. In the first place, there appears to be at present a sincere appreciation of the growing difficulties of driving and operating commercial vehicles both at home and abroad, so that greater attention is now being paid to improving the degree of comfort and the standard of visibility offered by cabs. Coupled with this is a tendency to extend the range of practical amenities—such as heating, radio and sound proofing—which can be offered to drivers.

Secondly, as fewer chassis manufacturers than formerly are now including in their standard range a choice of cabs for home or export conditions, designs capable of withstanding world-wide operational extremes are essential, and these, furthermore, must be devised to facilitate shipments in either knocked-down or partly dismantled form. Thirdly, in order to meet demands for lighter bodywork, particularly from home operators, designers are seeking to save weight in cab structures so as to achieve the required relation of payload to unladen weight, without increasing the initial cost or reducing standards of durability.

As a result the composite coachbuilt cab is rapidly disappearing on vehicles for operation in this country, having long since done so on export vehicles. A far greater degree of standardization than previously is thus becoming evident. This means that not only is the same cab being used on different models in a particular range, but also that the same cab is being used, with suitable superficial modifications of exterior appearance and appropriate rearrangement of mounting methods, on competitive makes of chassis in the same general category. In addition, great interest is being shown in the application of new materials to cab construction.

Typifying the situation is the forward control cab made by Transport Equipment (Thornycroft) Ltd. A pressed steel cab of modern design is standardized on Thornycroft 4-, 6-, 7- and 8-ton chassis. It can be removed by undoing four bolts, removing the steering wheel, and uncoupling an electric connection, leaving only the floor and base of the cab on the chassis. Following the general lines of this design, this manufacturer has produced a resin-bonded, glass-fibre cab which weighs between 112-168 lb less than the all-metal unit. The standard pressed steel sub-frame, which incorporates the engine cowling, wheel arch pans, valance, and front mudguards, is retained. Nearly all the remainder of the cab structure, the roof, back, quarter panels, screen framing, and front apron, are formed from resin-bonded glass fibre mouldings. The roof and back, which splits horizontally in the middle to facilitate removal for shipping, have a built up central spine, on each side of which the moulding is stepped downwards to provide rigidity without the use of framing members. The cab shell is bolted to the sub-frame, which is on rubber mountings on the chassis. The windscreen and fixed, front-quarter lights have brass frames set in the shell. An indication of the strength of the shell is revealed by the fact that the front quarter pillars of the glass-fibre cab are thinner than those used in the pressed steel unit.

For exhibition, this cab recently was shown with a flock-sprayed interior finish, but the natural qualities of the material should provide a high degree of sound deadening, while the ability of the material to withstand temperature variations, humidity changes, and deterioration through contact with oil, petrol, water, grease, and most chemicals are further practical virtues. The cab should prove capable of absorbing impact stresses, and, of course, lends itself readily to low cost repair in the case of accidental damage.

Another manufacturer with experience of glass-fibre resin-bonded components, is Jensen Motors Ltd. This company's light-alloy chassisless 7-ton forward control vehicle has for some time been produced with glass-fibre doors, seat pans, and radiator grilles, while on truck models, glass-fibre one-piece moulded roofs have been used where suitable.

However, the advantages of this type of material are not only appreciated by series manufacturers. A company that specializes in light alloy bodywork, Arlington Bodybuilders Ltd., has recently produced a number of cabs and bodies with glass-fibre roofs. In an Albion forward control lorry shown at Earls Court, a one-piece moulded roof was used. This was left unpainted, so that the interior of the cab was pleasantly illuminated by natural light. Compared with the light alloy roof normally used on such vehicles, the moulded component provides a worthwhile reduction in weight, and at the same time is cheaper than the normal domed, panel-beaten roof. One weight-saving feature of this company's cabs is that a flat, single pane, fixed windscreen is used in preference to the heavier, conventional, two-panel screen. To ensure a high standard of visibility, wide, curved Perspex quarter lights are provided on each side of the main screen, which is of toughened safety glass.

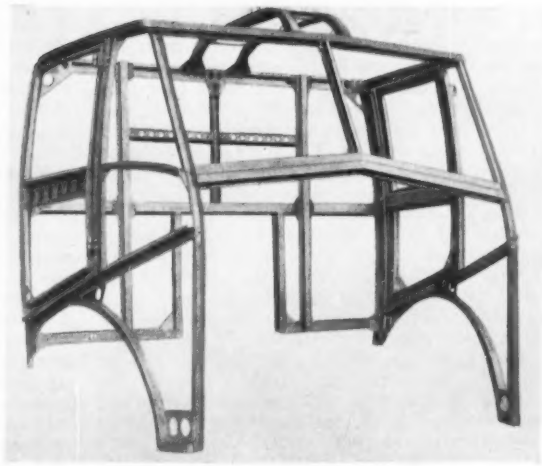
Where light weight is not a primary consideration, and where a particularly impressive vehicle is required for home operation, the composite cab has many advantages. One of the best examples of modern composite cab design, is the new KV cab on the E.R.F. vehicles. The conventional ash framing and aluminium panelling call for no particular comment, but the general arrangement of the cab is praiseworthy. Two fixed screens curved at the outer edges through almost 90 deg provide an exceptional, uninterrupted field of vision from the driver's seat. The screen glasses are also unusually wide and deep, and extend back to the front door pillar, eliminating the front corner pillar and any blind-spot that this might cause. The screen glasses are dropped slightly at the sides where, in conventional cabs, vision is frequently least satisfactory.

All the panelling is simple in shape, avoiding both deep and complicated sections. The centre front panel is

Curved screen-panels extending back to the front door-pillars give exceptional visibility from this E.R.F. composite cab, which has many luxury fittings

slightly curved in the vertical and horizontal planes, and can be removed for access to the engine. A polished, light alloy moulding running from the small central radiator grille conceals the joint between the upper and lower sections of the one-piece, wrapped front and side panels, the lower parts of which can be easily removed for repair or access. There are no external mud wings, protection being provided by the skirt panelling.

Internally the cab is also interesting, because to overcome criticisms on the absence of opening windscreen panels, a useful feature in fog or icy conditions, twin demister-heater units are fitted as standard. This is an unusual item in a vehicle of this class. One unit is installed on each side of the engine cowling, where it is behind the interior panel lining. Another unusual interior fitting is an ash-tray, recessed in the body side in front of the doors.



Extruded top hat sections, gusset plates and some channel sections form the framing of the Bowyer Bros. light alloy cab

However, luxury cabs of this type are rare even on heavy vehicles, although such details as vertically and horizontally adjustable seats are common. They are found, for example, in the new forward control cab introduced recently by Leyland Motors Ltd. for mounting on all its forward control models. This is an all-metal structure, double-skinned throughout with inter-panel insulation. This detail, and the fact that the cab can be erected from a comparatively small number of major jigged units—notably the floor, rear bulkhead, front assembly, roof and doors—make this entirely suitable for home or overseas use. The entire cab is built up of light gauge pressings, with top-hat section sticks and purlins to stiffen the roof, and angle sections to perform the same function in the back.

The interior lining panels are attached by hollow rivets, while the main structure is assembled with solid rivets, except in components such as the screen centre pillar and rear bulkhead, where spot-welding and bolting are also employed. Installation of heating and demisting equipment is simple, and for ventilation the forward quarter lights are arranged to swivel. The radiator grille, contained in the detachable front centre panel, is of polished Birmabright, and the bumper is bolted to the chassis frame. Plates in the floor are provided to accommodate auxiliary equipment controls, such as winches and trailer brake gear.

This cab is produced by Bonallack and Sons Ltd., who also make an attractive all-steel cab for the A.E.C. Mercury chassis. Unlike the majority of such cabs, it has curved rather than flat main panels; both cleaning and repair should prove particularly easy. The cab is comprised of roof, scuttle, front-side, door, floor and back pressings. Several folded channel sections form the built-up, screen framing. The centre pillar is welded into position and located by small channel section brackets in the main framing pressings. Like most cabs of this type, it is designed to split at waist level, so that when a vehicle is shipped complete with cab, its overall height is only the distance to the top of the steering column, the roof, screen and back of the cab being shipped on the chassis behind the cab.

Another type of cab built by this concern is a light alloy unit, based on extruded section framing with unstressed panels. Equipped with forward sliding doors, the complete cab weighs only $2\frac{1}{4}$ cwt, fully painted and trimmed. Another cab of similar type is built by Bowyer Bros. (Congleton) Ltd. A detail of this design is that top-hat section extrusions are used in the framing

Spot welded, pressed steel panels form the structure of this Albion cab made by Autolifts and Engineering Co. Ltd. The roof and lower half are bolted together to facilitate dismantling

This Morris Commercial cab is typical of the standard all-steel cab used by a number of chassis manufacturers. A detachable top and pivoted quarter lights are features of the design

wherever possible in preference to folded sections. The framing is assembled with simple brackets and gusset plates at highly stressed points, using high tensile bolts and proprietary lock-nuts, and the 18-gauge panelling is attached by Chobert rivets.

An interesting comparison with light alloy cab structure such as this is provided by another pressed steel cab designed for fitting on similar chassis. This is the forward control cab produced by Autolifts and Engineering Co. Ltd. for Albion chassis. Pressed steel panels with pressed stiffeners for the rear, roof and front panelling are assembled by welding, except at the waist level where the sections are bolted together to facilitate removal of the top for shipping. The doors are constructed of welded inner and outer pressings, and the roof is double-skinned, with asbestos insulating the inter-panel space. Complete with twin screens, fixed quarter lights, adjustable driver's seat, etc., the cab weighs 4¾ cwt.

Similar in many respects are the cabs produced by Willenhall Motor Radiator Co. Ltd. for use on such vehicles as the Morris-Commercial forward control 5-tonner and others. Apart from the sub-structure, the cab consists of roof, doors, sides, rear and front panelling. It is designed to split at the waist, and the shallow pressings are assembled by spot welding. The front quarter lights swivel for ventilation, and the detachable front panel, concealing the radiator, is designed to accommodate a variety of grilles, to meet the chassis manufacturers' needs. As in most pressed steel cabs of this type, the panels are produced in pairs, and split. Apart from the economy obtained by this method of production, it ensures that left or right hand controls can be readily accommodated.

A case in which both production and maintenance problems have been eased by the use of an unconventional material is seen in the cab of the new Mann Egerton integral light alloy truck. The cab is a full forward type, ahead of the front axle. It is framed in welded light alloy extrusions, to which embossed, 20-gauge aluminium alloy panels are attached by solid rivets. The design of the vehicle was carried out by the development department of the British Aluminium Co. Ltd., in conjunction with Mann Egerton Ltd. and Dennis Bros. Ltd., and the vehicle is one of the first with this type of exterior panelling.

Produced by British Aluminium Co. Ltd. for applications of this type, the "stucco" finish of this embossed panelling requires no painting, and scratches occurring in service are not easily discerned. The embossing also has the effect of reducing drumming. Conventional vertically swaged panels are used at the rear of this cab, while chequer plate flooring is employed. A 16-gauge, high strength alloy crash plate is fitted inside the front panelling, and the cab is mounted on four rubber units of the conical type. Exterior mouldings on this cab are produced from a new, bright finished aluminium which requires no polishing. Since the engine in this vehicle is under the centre of the chassis, the cab is entirely clear of mechanical components.

INSTITUTION OF MECHANICAL ENGINEERS

Forthcoming Meetings of the Automobile Division

The following meetings will be held during December :—

LONDON

Tuesday, 14th December, 5.30 p.m. General Meeting at 1 Birdcage Walk, Westminster, S.W.1. Paper: "Some Problems in Lubrication and These Substances called Additives," by A. Towle, M.Sc. (Member).

COVENTRY CENTRE

Tuesday, 7th December, 7.15 p.m. Craven Arms Hotel, High Street. Paper: "Tyre Characteristics as Applicable to Vehicle Stability Problems," by T. J. P. Joy (Associate Member) and D. C. Hartley.

DERBY CENTRE

Monday, 6th December, 7.15 p.m. Midland Hotel. Address by the Chairman of the Automobile Division, J. H. Pitchford, M.A. (Member), entitled "Engine Research and Development as a Service to Industry: A Personal Experience."

LUTON CENTRE

Monday, 13th December, 7.30 p.m. Assembly Room, Luton Town Hall. Paper: "Some Problems in Lubrication and These Substances called Additives," by A. Towle, M.Sc. (Member).

NORTH-WESTERN CENTRE

Wednesday, 15th December, 7.15 p.m. Engineers' Club, Manchester. Paper: "The Two-Stroke Diesel Engine and its Application to Commercial Vehicles," by J. C. Morrison, Ph.D., B.Sc. (Member).

SCOTTISH CENTRE

Monday, 20th December, 7.30 p.m. Institution of Engineers and Shipbuilders, 39 Elmbank Crescent, Glasgow. Paper: "Production Problems in Commercial Vehicle Manufacture caused by New Models," by D L. Campbell, B.Sc. (Glas.), (Associate Member).

WESTERN CENTRE

Thursday, 30th December, 6.45 p.m. Royal Hotel, Bristol. Informal Meeting.

The following meetings will be held during January:—

LONDON

Tuesday, 11th January, 5.30 p.m. General Meeting at 1 Birdcage Walk, Westminster, S.W.1. Three Papers on "Vehicle and Road Lighting," by L. J. Davies, G. Grime, M.Sc., and J. L. Nelson, Ph.D., B.Sc. (Associate Member).

BIRMINGHAM CENTRE

Tuesday, 4th January, 6.45 p.m. James Watt Memorial Institute, Great Charles Street. Paper: "Vehicle and Illumination," by J. H. Nelson, Ph.D., B.Sc. (Associate Member).

Tuesday, 25th January. Paper: "Commercial Vehicle Structure," by P. Brunton.

COVENTRY CENTRE

Tuesday, 4th January, 7.15 p.m. Craven Arms Hotel, High Street. Paper: "Some Problems in Lubrication and These Substances called Additives," by A. Towle, M.Sc. (Member).

Graduates' Section

Wednesday, 19th January, 7.30 p.m. Craven Arms Hotel. Address by Major A. P. Rolt.

DERBY CENTRE

Monday, 31st January, 7.15 p m Midland Hotel. Paper: "Rocket Propulsion," by Professor A. D. Baxter, M.Eng. (Member).

LUTON CENTRE

Monday, 10th January, 7.30 p.m. Assembly Room, Luton Town Hall. Address by the Chairman of the Automobile Division, J. H. Pitchford, M.A. (Member), entitled "Engine Research and Development as a Service to Industry: A Personal Experience."

NORTH-EASTERN CENTRE

Wednesday, 19th January, 7.15 p.m. Chemistry Lecture Theatre, The University, Leeds. Paper: "The Skid-Resisting Properties of Tyres and Road Surfaces," by G. Grime, M.Sc., and C. G. Giles, B.Sc., and "Investigations into the Braking Performance of Road Vehicles," by H. J. H. Starks, Ph. D., and R. D. Lister (Associate Member).

NORTH-WESTERN CENTRE

Thursday, 20th January, 7.15 p.m. University of Liverpool, Walker Buildings, Brownlow Hill. Paper: "Recent Developments in the Road Transport and Handling of Bulk Sugar," by C. H. Williams (Associate Member).

SCOTTISH CENTRE

Monday, 17th January, 7.30 p.m. Institution of Engineers and Shipbuilders, 39 Elmbank Crescent, Glasgow. Paper: "The Running-in of Engines: Choice of Cylinder Bore Finish," by K. R. Williams and S. G. Daniels.

WESTERN CENTRE

Thursday, 27th January, 6.45 p.m. Royal Hotel, Bristol. Paper: "Production Problems in Commercial Vehicle Manufacture Caused by New Models," by D. L. Campbell, B.Sc., A.M.I.Mech.E.

MECHANIZED WELDING

Developments by D. Napier and Son Ltd. for Argon Arc Processes

INERT-GAS-SHIELDED welding processes are acknowledged to have considerable advantages, particularly for the welding of light alloys. Their use for this purpose has been the subject of an intensive development programme at the Luton Establishment of Messrs. D. Napier & Son Ltd., and in particular, their mechanization has received attention. Both the tungsten electrode and consumable electrode processes are in use, and this article deals primarily with the development of equipment for mechanized application of these processes.

Most of the work has been carried out on the heat-treatable aluminium alloys H.10 and H.15. Both of these are hot-short and present some difficulty when butt-welds several feet long have to be made. By mechanization, welding conditions may be closely controlled and repeated, welders become proficient more rapidly, and the welds are more uniform in quality and dimensions.

Early work proved that vibration was one of the most serious obstacles to satisfactory mechanical welding, and steps have been taken on all recent equipment to deal with this problem. Wherever possible, the work is traversed under a stationary torch, and rubber couplings have been incorporated into the work-traversing mechanism at all points where parts are rotating sufficiently rapidly to set up vibratory disturbances.

Instability of the arc, which is a frequent cause of faulty welds, can be due to a number of factors, besides vibration. For example, the magnetic field associated with the arc can induce instability if there is a lack of symmetry in the disposition of ferrous materials adjacent to the line of welding. Jigs and backing arrangements should therefore be set out with careful attention to this point. A further cause of faulty welds, connected with material preparation, is discussed later.

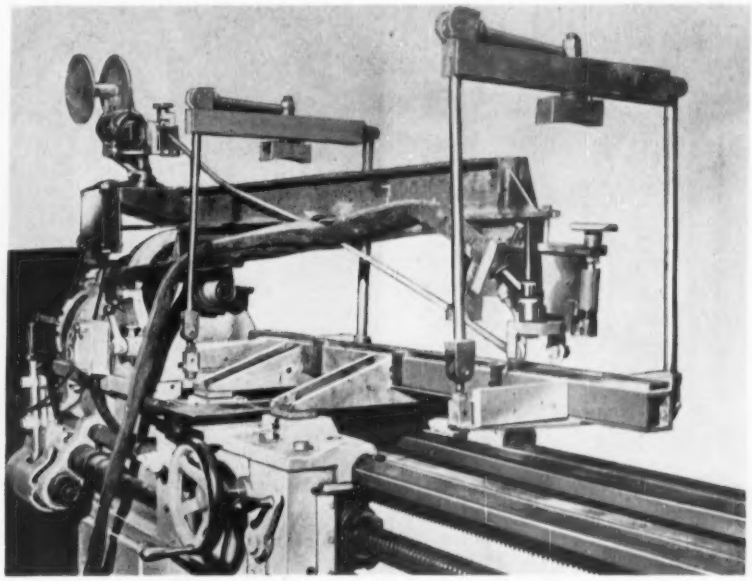


Fig. 1. An early longitudinal welding machine adapted from a lathe for cylinder welding

These limitations led to experiments to determine the relative merits of welding from the inside, with external backing, or *vice-versa*. It has been established beyond doubt that inside-outwards welding is the better method, as the component, when heated during welding, expands into more intimate contact with the backing bar. Particularly in the case of circumferential welds, the result is a neater weld and a more accurate product.

Fig. 1 illustrates an early machine for longitudinal welding which was adapted from a lathe. The tailstock and compound slide rest were removed, and a cantilever beam was mounted over the headstock to form a support for the torch, which may be seen, secured to a pivoted plate that incorporates guide rollers. These are in contact with the work during welding, and maintain the arc gap at a preset dimension. The filler rod feeding arrangements may also be seen in the illustration. Stainless steel tube extending into the argon envelope around the weld protects the wire against atmospheric contamination. Originally chain-driven, this machine has been converted to a gearbox and shaft drive, and in the form shown in Fig. 2 is now used for development work on flat test plates.

For production welding it has been replaced by the machine depicted in Fig. 3. Once again a lathe bed has been used as the basic structure, but in this case all parts except saddle and lead screw were removed. The stationary torch is mounted centrally in the box-section light alloy beam, which runs the

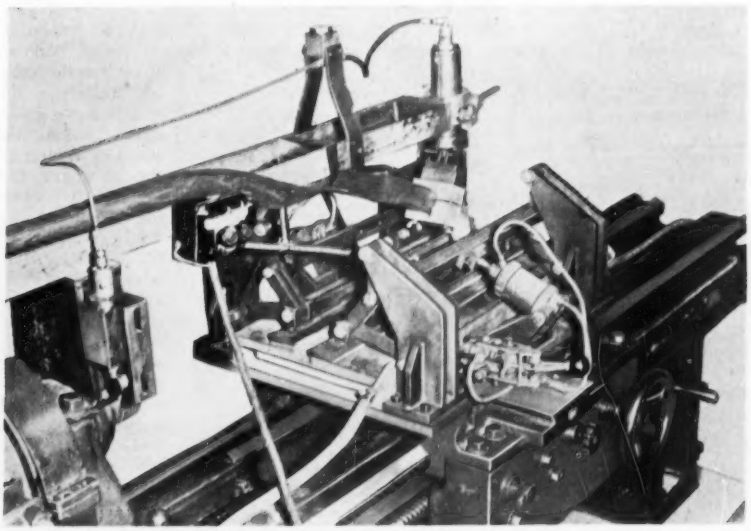


Fig. 2. The machine shown in Fig. 1 modified for development welding. There are facilities for controlled pre-heating

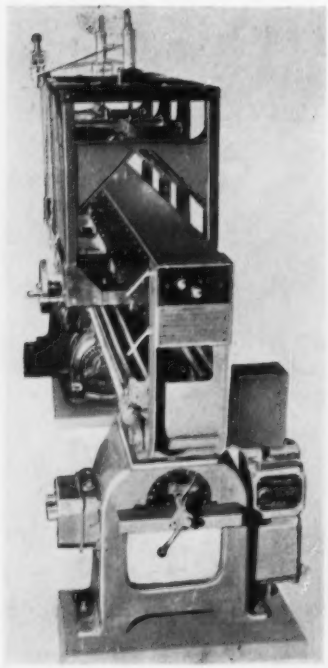


Fig. 3. Longitudinal welding machine used in the production of cylinders

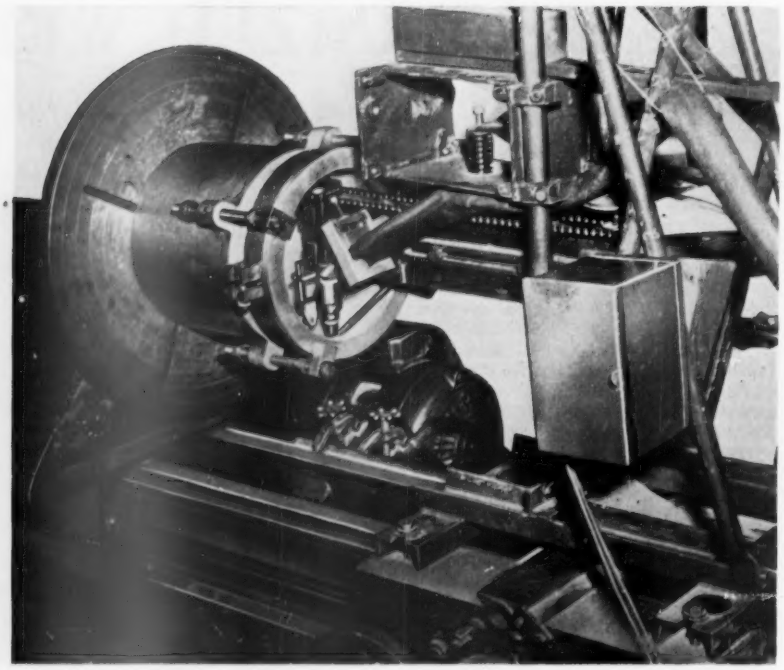


Fig. 4. Circumferential welding machine with elevated faceplate and adjustable torch support to accommodate a range of diameters and weld positions

full length of the machine and is strongly supported at both ends. One end support may be lowered to permit the introduction of the work into the support cradle, in which it is secured by pneumatic clamping. The wire feed unit is housed in the beam, at the far end, and its control, together with others for traverse rate, arc length, etc., is brought to a common operating position. Steplessly variable current and traverse rate controls are provided, the former by a remotely operated phase-shift system, and the latter by means of a Kopp Variator.

Mechanized circumferential welding is performed on the machine shown in Fig. 4. This machine, too, is based on a lathe, to which has been added a supplementary headstock spindle, thus extending its capacity. The drive is through all the lathe gearing on to the leadscrew, whence the motion is transmitted by chains to the faceplate. In this way, a wide range of rotary speeds is available, supplemented by the inclusion of a Kopp Variator which gives the stepless control required for a special welding technique described later. Filler rod is fed to the weld from the rear, as depicted in the illustration, where the machine is set up for inside-outwards welding of a flange on to a small spun tank.

In mechanical welding, as many as possible of the controls should be steplessly adjustable, preferably whilst welding is in progress. This has been achieved in the case of all variables, the welding current being drawn from either the phase-shift controller previously mentioned or from a motorized moving core reactor. Both these control systems were devised and manufactured by the English Electric Company Ltd. Kopp Variators, incorporated into all the welding machines, give stepless control of traverse rate. Arc length and filler rod feed are also continuously adjustable.

It has been found that high rates of traverse lead to porous welds. This is thought to be due to gases released from the materials being trapped by the rapidly-solidifying weld metal. It is certain that a reduction of traverse speed does bring about an improvement in weld quality. This phenomenon is not so much a feature of consumable electrode welding as it is of the tungsten Argon Arc process.

Of several arc length control systems in use, that shown in Fig. 5 is of particular interest. It is a closed hydraulic circuit, with a flexible metal bellows at each end. Axial compression of one bellows by a cam causes an equal extension of the other, and this is used to adjust the height of the torch relative to the work. The advantage of this system over one using mechanical linkages is that although there may be a considerable distance between the control point and welding torch, no backlash is encountered.

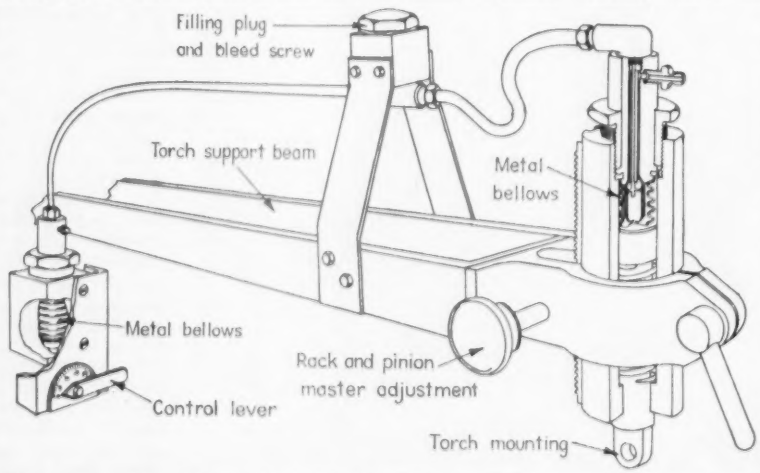


Fig. 5. A sensitive and adaptable hydraulic system of arc-length control based upon two flexible bellows units

Until 500 amp American welding torches became

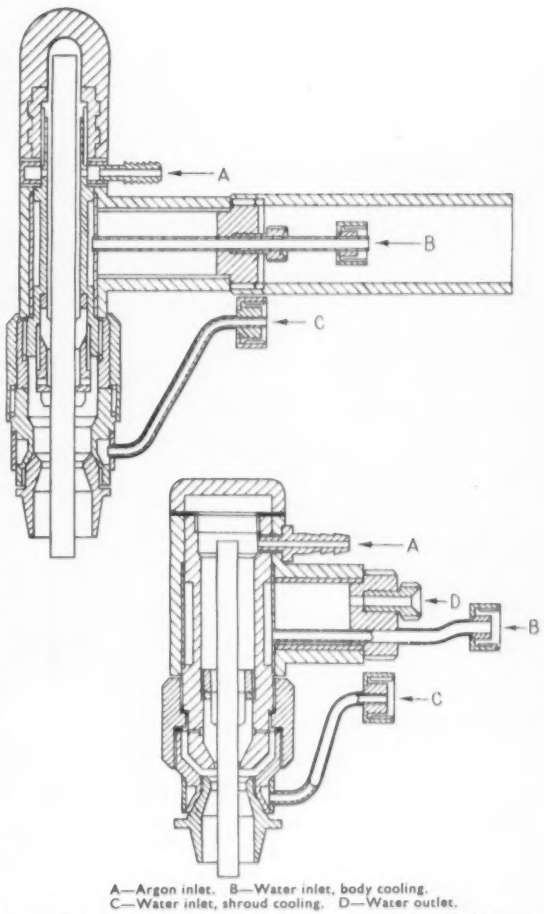
available, high welding current values made it necessary to develop special torches for this work. The two latest designs are illustrated in Fig. 6. These torches have proved themselves able to carry a continuous welding current of 800 amps, and with them it has been possible to produce single pass 90 deg close-butt welds in HP.10 plates $\frac{1}{4}$ in thick. No vee preparation of the edges was necessary.

Tables I and II show a number of typical settings which have been used with successful results. It should be noted, however, that it is seldom possible for other users to adhere to recommendations such as these, since size and shape of work piece and jigging arrangements all affect the conditions ultimately chosen. Each assembly requires individual treatment and it is usually necessary to carry out tests to obtain optimum settings.

Backing bar design is a subject on which much work has been done, and certain aspects of the matter are still being investigated. The result of experimental work to date is that the best form of backing bar incorporates a groove of circular arc form, 0·070 in to 0·080 in deep in the centre, the groove width being 0·35 in. Mild steel has been found suitable as a backing bar material for use with light alloys, and it must be remembered that expansion of the bar takes place during welding. It should therefore be fixed rigidly at only one point; side clamping, such as may be seen in Fig. 1 to allow expansion to occur without causing buckling.

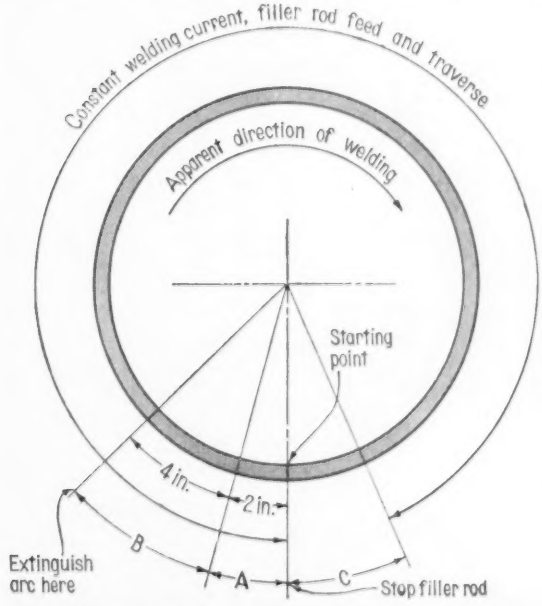
By itself, suitable tooling is not enough to ensure a satisfactory weld. Attention must be paid to the preparation of the edges to be joined, as very poor welds will result if they are left rough-cut with a varying gap between them. The butted edges of the work should be machined parallel, and it is vitally important that the two components should present a flat surface within 0·10 in at the line of weld. If, due to differing thickness of material or poor jigging and fit-up, these conditions are not met, severe centreline porosity can result.

It has been found that with a 90 deg close-butted form of edge preparation, single-pass, full penetration welds may be made on material whose thickness lies between $\frac{1}{8}$ in and $\frac{1}{4}$ in having regard to availability of appropriate equipment. Thinner materials have been successfully butt-welded, down to 16 S.W.G., but a lipped edge preparation is more satisfactory in these cases. The above remarks apply to tungsten arc welds only, a vee preparation having been found necessary for consumable electrode welding of all except the thinner gauges. Single-pass welds by this process are, in our experience, limited to a thickness of $\frac{3}{16}$ in, above which a multi-run method should be employed.



A—Argon inlet. B—Water inlet, body cooling.
C—Water inlet, shroud cooling. D—Water outlet.

Fig. 6. Recent welding torch designs capable of handling 800 amps continuously



A—Welding current and traverse as at C. B—Reduction welding current and increase traverse. C—Slightly reduced welding current.

Fig. 7. Operational sequence for circumferential welding

It will be found useful in some cases to tack-weld the parts together by hand before mechanical welding, but tack-welds are not strong enough to maintain the close-butted edges unaided, and mechanical clamping of the work is always necessary. If accurate fit-up of the parts can be effected by mechanical means, it is considered preferable to omit tack-welding altogether.

Following the techniques of tooling and edge-preparation already described, welding together of wrought and cast components has been undertaken with success, and several fabrications comprising rolled or spun sheet are being welded to cast flanges and other details. In this connection, castings in D.T.D. 245 are welded to HS.10, using aluminium-11 per cent silicon filler rod (D.T.D.245 composition). The same filler rod is used for HS.10/HS.10 work, while that employed in welding HS.15 material is of parent metal composition. Preliminary work on D.T.D. 687 type alloys (unclad) indicates that these materials can be welded successfully with filler rod of the same composition. A development programme on the welding of magnesium-based alloys indicates that all those tested, except Magnesium-Elektron specification Z5Z, are mutually weldable, using filler rod to specification Z2Z2C.

During the development work with which this article is concerned, certain special techniques were evolved. Two of these are of particular interest. The first concerns the production of circumferential Argon Arc welds free from the deep finishing crater normally found at

TABLE I.—TUNGSTEN ARC WELDING

Material		Amps.	Trav. Rate (in/min)	Filler Rod			Electrode Dia. (in)	Argon Flow (ft³/hr)	Remarks
Spec.	Thickness (in)			Spec.	Dia (in)	Feed (in/min)			
NP.6	0·5	635	3	NW.6	1/8	12/14	3/8	22	Two Pass
			3	—	—	—	3/8	22	
NP.6	0·75	690	1 7/8	NW.6	1/8	8	7/16	24	Single Pass
NP.6	0·75	720	1 3/4	NW.6	1/8	6	7/16	24	Single Pass
HS.15	0·192	297	4 3/4	HW.15	1/8	10/12	1/4	23	Single Pass
D.T.D.687	0·192	300	5	D.T.D.683	1/8	14	1/4	23	Single Pass (Unclad Mat.)
HP.10	0·3	485	4 1/2	D.T.D.245	1/8	16/18	5/16	20	Single Pass
HS.10	0·128	300	4 1/2	D.T.D.245	1/8	16/18	1/4	20	Single Pass
ZW.3	0·75	585	4 1/4	Z2Z2C	1/8	20	3/8	30	Single Pass
ZW.3	0·5	550	4 1/2	X2Z2C	1/8	28	3/8	30	Two Pass Alternate Sides
		433	4 1/4	Z2Z2C	1/8	24	3/8	30	
ZT1 & ZRE1	0·25	400	10	Z2Z2C	1/8	19	5/16	30	Single Pass

TABLE II.—CONSUMABLE ELECTRODE WELDING

Material		Volts O.C.	Volts Arc	Amps	Filler Rod			Argon Flow (ft³/hr)	Remarks
Spec	Thickness (in)				Spec	Dia (in)	Feed (in/min)		
HS.10	0·25	80	26	240	HW.15	1/16	235	60	Single Pass Automatic
HP.10	0·5	80	23	260	D.T.D.245	1/16	230	60	Three Pass Manual
HS.10	0·192	80	25	270	D.T.D.245	1/16	235	60	Single Pass Manual
HS.15	0·192	80	25	260	HW.15	1/16	230	60	Single Pass Manual

the end of a run. In this special technique, the weld is initially made in the normal manner with filler rod addition. When the work has completed a revolution under the torch and the original starting point is reached, the filler rod feed is stopped, and rotation of the work under the arc is continued. After an overlap of about 1½ in to 2 in, the welding current is smoothly reduced, and at the same time the electrode is raised and the traverse speed increased, with the result that penetration is progressively lessened. At the moment of extinction of the arc the depth of molten metal does not exceed 1/32 in and the minute crater which results is totally contained in the built-up metal formed during the first run. Fig. 7 illustrates this technique.

Another special process which has been developed is used for the addition of lugs to the wall of the pressure cylinder in Fig. 8. The method is to trepan a hole in the cylinder wall and insert a cast part which comprises the necessary projections, together with replacement material for the portion of cylinder wall which has been removed. A full-penetration weld is then made around the periphery. The cylinder material is HS.10, and the insert is to specification D.T.D.245, with the latter material as filler rod. To meet design requirements, the tensile strength of the material has to be restored. It is recovered by heat-treatment.

A process employed for accurate sizing of cylinders produced by welding has been incorporated into the heat-treatment cycle, in the following way. H.10 and D.T.D.245 materials both respond to a two-part heat-treatment operation embodying solutionizing at 535 deg C, and after quenching in water, precipitation at 170 deg C. As soon as the solutionizing process is completed, the component is removed from the furnace and placed over a cast iron or mild steel mandrel as quickly as possible. Both cylinder and mandrel are lowered into the water quenching tank, and the chilled cylinder shrinks into intimate contact with the mandrel. They are then replaced in the furnace for precipitation. During this process, the expansion of the light alloy relative to the mandrel at the treatment temperature is sufficient to free it, thus allowing easy removal. Cylinders 18in in diameter and 4 ft long have been trued up in this manner in two stages on successively larger mandrels, the result being a product which is completely straight, and on which a diameter tolerance of plus or minus 0·005 in may be held. Fig. 9 illustrates a cylinder undergoing this treatment, and shows one of the mandrels which are used.

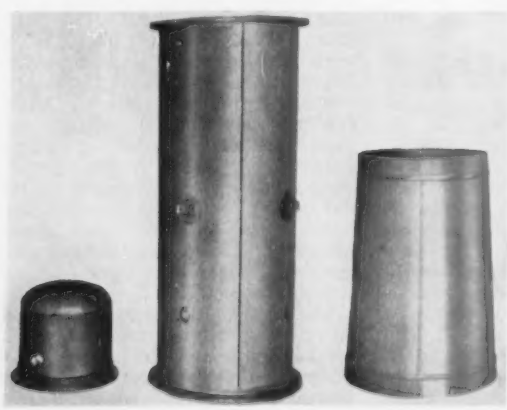


Fig. 8. Typical mechanically welded fabrications

Fig. 9. Part of the heat treatment department

TABLE III.—TYPICAL MECHANICAL PROPERTIES OF LIGHT ALLOY BUTT WELDS AFTER HEAT TREATMENT

Parent Material	Filler Rod	Welding Process	Properties—Fully Heat Treated					
			Specification			Welded		
			U.T.S.	0·1 per cent P.S.	El per cent	U.T.S.	0·1 per cent P.S.	El per cent
HS.10	HW.10	Tungsten	19	15	8	20·8	17·0	4·0
HS.10	D.T.D.245	Tungsten	19	15	8	20·7	18·5	2·0
HS.15	HW.15	Tungsten	26	20	8	28·2	21·02	4·0
HS.15	HW.15	Cons. Elect	26	20	8	29·6	24·3	5·1
D.T.D.687	D.T.D.683	Tungsten	32	27	8	32·6	29·7	1·5

All stresses are in ton/in². D.T.D.687 Material was unclad.

As far as restoration of mechanical properties is concerned, Table III gives details of typical results achieved.

Fig. 8 illustrates three typical light alloy fabrications, the flanges being of cast D.T.D.246 attached to the wrought components (of HS.10) by circumferential welds. Two are required to sustain high internal pressure, and all must conform to close dimensional tolerances. The item at the left is produced as a 10 gauge HS.10 spinning, and the position of the weld indicates that the flange incorporates a portion of the body, making a butt welded joint possible. The circumferential welds on the middle item are similarly placed, and in this case the wall thickness of the vessel is 0·3 in. The third piece in Fig. 8 is a unit which is mechanically welded using the Argon Arc process, and although not pressurized, is a structural component in which dimensional accuracy is vitally important.

Mechanized welding is a specialized subject, and its requirements should be understood by those responsible for designing components on which it is to be employed. They should be advised of the dimensions of welding torches, and where necessary, of welding machinery, so that joints are placed where access to them may be most conveniently obtained. Drawings should indicate clearly from which side the weld is to be made, and designers should bear in mind the fact that it is going to be necessary to apply and remove a backing bar. They should also consider the special provisions which it may be necessary to make to allow for machining after heat-treatment. It has been established that the most satisfactory form of Argon Arc weld is the full penetration, 90 deg close-butted joint, fillet welds being avoided wherever possible. Not only is this type of weld better from the point of view of radiological and visual examination, but the chances of success in obtaining a sound joint are considerably improved.

Alongside the current production programme, development work related to mechanized welding continues, and a number of interesting problems are under investigation. Included in this work is the development of a technique for producing crater-free longitudinal welds, so that a scrap allowance need not be made at the ends of the component. Work is also in progress on a series of experiments which are in the nature of a research into the fundamentals of argonarc welding of light alloys, so that the scope of mechanization may be increased.

ENGINE TESTING

Interesting New Plant Installed by David Brown Tractors (Engineering) Ltd.

A NEW engine test house, believed to be one of the most advanced in the country both in layout and equipment, has recently been put into operation by David Brown Tractors (Engineering) Ltd. at their Farsley Works near Leeds. Experimental work carried out at Company's headquarters at Meltham has largely determined the design and methods chosen for the new test plant. It will be used for running-in and power-testing the engines assembled at Farsley for fitting in David Brown agricultural and industrial tractors and in Lagonda and Aston Martin cars.

One notable feature of the plant is that no less than five fuels are laid on direct to the test beds. Coal gas is normally used for running-in purposes but alternative fuels are available if required. Each engine, after the running-in, is power-tested on the fuel for which it is specifically designed. On account of the wide variety of tractor engines manufactured to meet the demands of farmers at home and abroad, it has been necessary to provide supplies of gas oil, vaporizing oil, petrol and lamp oil. They are all fed from storage tanks alongside the main building.

The original testing and running-in plant comprised 12 tractor engine beds and two car engine beds, all fulfilling dual roles. In the new test plant there are 17 dynamometer test beds and nine running-in beds for tractor engines, and three test and three running-in beds for car engines. Provision has been made for further development to almost double the capacity, should this be required. The bases for the additional beds have been laid as part of the general scheme.

Adjacent to the main works, the new building is a self-contained unit 250 ft long by 37 ft 6 in wide. Fuel and water supplies have been laid in covered trenches to give the maximum floor area clear of obstructions.

As water is used as the hydraulic medium in the dynamometers as well as for cooling purposes, the plant has been equipped with a pumping house and cooling system to effect recirculation. The main tank, of 20,000 gallons capacity, is divided into hot and cold sections. Water from the cold section is supplied to the dynamometers and to header tanks on each test bed by a pump capable of delivering 15,250 gallons per hour.

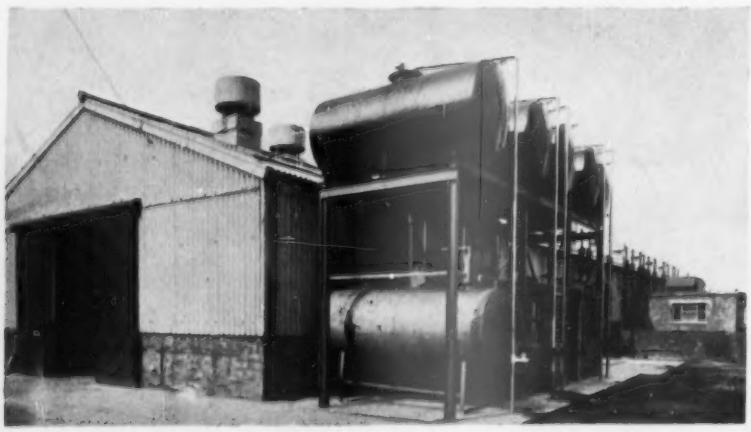
Hot water, when discharged, flows into a common trench to be returned by gravity flow to the hot well in the reservoir. A second pump, also of 15,250 gallons per hour capacity, passes the hot water to a cooler, from which it discharges into the cold tank at a temperature of not more than 100 deg F in summer conditions. Another pump circulates water through an oil system on the car engine beds. Each of the pumps is duplicated, one to operate on load and the other on reserve. Thus a breakdown in the circuit cannot bring the whole plant to a standstill.

Bulk storage tanks for fuels and lubricating oil are situated outside the building. The fuels flow by gravity to the engines, and the lubricating oils are fed under pressure to the running-in beds. Petrol is stored in an underground tank of 1,000 gallons capacity. From this tank it is pumped to a 50-gallon header tank and thence to the test beds. Overhead tanks are used for storing gas oil and vaporizing oil. The respective capacities are 2,000 and 1,000 gallons. Since comparatively few engines are built to operate on lamp oil, only 500 gallons of this fuel are stored to feed two test beds.

Unused and purified lubricating oils are stored in separate tanks, each of

Interior layout of the new David Brown engine test plant

One of the insulated cubicles for tests on Lagonda and Aston Martin engines



Fuel storage tanks

1,000 gallons capacity. When an engine is drained on the test bed, the used oil is piped to underground tanks. Its condition is then tested, and the oil is either disposed of as waste or is passed through a motor-driven centrifugal purifier and returned to the overhead tanks for further use. A gauge incorporated in the pressure flow system makes it possible to measure accurately the quantity of oil for the engine.

The decision to use coal gas for running-in was made on the grounds of both economy and efficiency. Coal gas is not only a cheap fuel, but also has the great advantage of leaving little solid deposit on combustion. For running-in, the initial impulse is provided by an electric motor, with a clutch that automatically disengages at 750 r.p.m. The gas supply keeps the engine running under its own power from then on. Hydraulic dynamometers are fitted throughout. The tachometers on the tractor beds record up to 5,000 r.p.m.

The high-speed car engines run in three sound-insulated cubicles in a separate section of the building. They are coupled to dynamometers installed outside the cubicles. Because of the high engine speeds these dynamometers have stainless steel elements and the latest type of electric tachometer, reading up to 8,000 r.p.m. The normal test speeds run up to 6,000 r.p.m. To reduce vibration to a minimum, the concrete bases of the car engine test beds are set in cork surrounds.

Noise outside the building has been kept to a minimum by piping each exhaust to an absorption type silencer mounted on an outside wall. Single-chamber silencers are fitted on the exhausts from the tractor beds, but the silencers for the much faster running car engines have primary and secondary chambers.

NEW DRY BEARING

The Glacier, DP Series Plain Bearings for Use Without Lubrication

A NEW range of bearings, for use without lubrication, has been introduced by Glacier Metal Co. Ltd., of Alperton, Middlesex. The bearings are of the steel backed, strip type and are lined with a porous bronze impregnated with the plastics material, polytetrafluoroethylene, commonly abbreviated to PTFE. These butt-jointed, wrapped bushes are identical in form to the well known Glacier range of Standard Wrapped Bushes. Thrust washers made from this material are also available in Standard sizes, and the strip can be supplied as flats for use on machine tool slides, etc. In the preparation of the lining material, a sheet of PTFE about 0·003-0·004 in thick is impregnated into the pores of the bronze until only a thickness of about 0·001 in of the plastics is left on the bearing surface.

Intensive rig and field tests over the past few years have demonstrated beyond doubt that in many applications, bearings of this type are satisfactory. However, it has not been possible yet to install them in every type of machinery working under all conceivable conditions. For this reason the Standard sizes of bearings have been made available so that the manufacturers may obtain bearings at an economical price for experimental use to satisfy themselves that the units will be satisfactory in their own particular applications. Special bearings, outside the range of Standards, can be manufactured economically if the quantities required are sufficiently large. Normally, it is uneconomic to produce less than 5,000 of any one type.

Polytetrafluoroethylene

PTFE is a plastics material consisting of carbon and fluorine combined chemically. It has a dry surface coefficient of friction of approximately 0·05. This is an unusually low value: it is comparable with that of ice, and is lower than the boundary friction usually obtained in conventional bearings, even with good lubricants. The low coefficient of friction is a surface property of the material and does not, as with such solid lubricants as graphite, depend upon the formation of a surface film of low shear strength. Thus, under ideal conditions, wear should not take place between the rubbing surfaces. However, conditions are never ideal, of course, and the wear that does take place is due to the roughness of the mating surfaces ploughing through the surface film of PTFE.

It follows that the surface finish of the journal is of importance; the manufacturers recommend that it should preferably be between 3 and 8 micro-inches, but the upper limit may be extended to 10 micro-inches. The recommended running clearance varies with the size and tolerances, but in general it is from zero to about 0·001 in. It is necessary for the clearance to be as small as practicable so that contact takes place over as large a projected area of the journal as possible. Standard tolerances for the fitment of pre-finished wrapped bushes are recommended for these bearings.

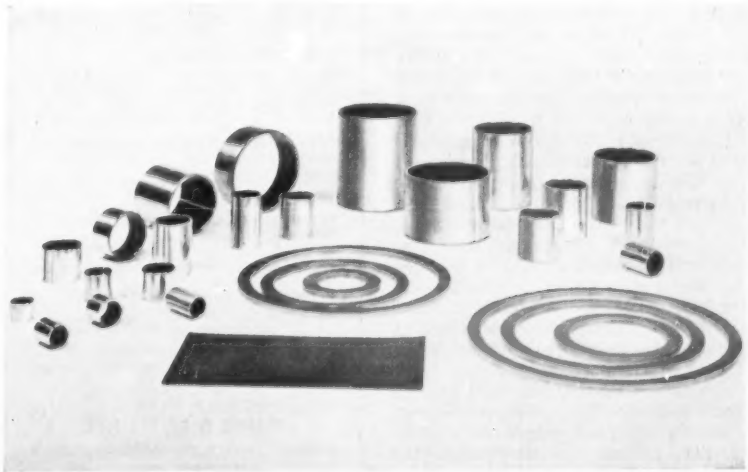
MAXIMUM PV FACTORS FOR DIFFERENT TYPES OF BEARING

Loading Conditions	Performance	
	PV, lb/in² × ft/min	Minimum life, hr
Thrust washers	5,000 2,000 15,000	1,000 10,000 Special*
Unidirectional load (E.g., bush fixed, shaft rotating, load fixed relative to bush)	3,000 1,800 8,000	1,000 10,000 Special*
Rotating load (E.g., bush rotating, shaft fixed, load rotating relative to bush)	12,000 7,500 30,000	1,000 10,000 Special*
Oscillating shaft (E.g., bush fixed, shaft oscillating relative to load, load fixed relative to bush)	18,000 12,000 60,000	1,000 10,000 Special*

*High PV values and/or longer life can be obtained by special treatment of journals or by careful selection of housing, bearing and journal sizes.

The plastics material is stable up to a temperature of 327 deg C. Therefore, these bearings can operate in an ambient temperature of about 280 deg C, since this allows an adequate margin for bearing temperature rise. They can be used satisfactorily in even higher ambient temperatures if they are cooled adequately to prevent undue rise in temperature at the working surfaces. The load carrying capacity of the bearings does not decrease a great deal with temperature up to about 150 deg C. For operation above this temperature, it is most important that the decreased load carrying capacity should be taken into account in the design. The chemical properties of PTFE are particularly favourable. The material is not attacked, dissolved or affected in any way by known organic or inorganic liquids, solvents, acids or gases, etc., except molten potassium, molten sodium and fluorine gas.

PTFE, of course, also has a number of disadvantages so far as application to bearings is concerned. It has poor thermal conductivity, a high coefficient of thermal expansion, dimensional instability, poor temperature stability, and in the cold state it tends to flow under light loading. It is to overcome these difficulties that the material is used not by itself but impregnated into a strong porous matrix of a metal which



A selection from the Glacier, DP Series range of plain bearings and thrust washers

has good bearing properties. The metal furnishes the necessary strength, thermal conductivity, and temperature and dimensional stability; and, because of the excellent frictional, chemical and wear properties of the PTFE, the combination of the two materials forms a bearing capable of carrying relatively heavy loading without lubricant.

Design aspects

The design criteria for dry bearings differ from those for lubricated ones. Whereas much of the heat generated can be carried away by a lubricant, there is no such cooling action in dry bearings. Thus, the load and speed capacities of dry bearings are determined largely by the ability of the assembly to dissipate heat, and the criterion is the PV factor, that is, the load in lb/in^2 of the projected area, multiplied by the surface velocity in ft/min. For thrust washers and oscillating shafts the mean velocity is used in this criterion. It should, of course, be borne in mind that details of the assembly will influence the load carrying capacity of the bearings, so the figures quoted in the Table of acceptable PV factors for different types of bearing are only approximate.

In general, the bearing action is as follows: During the first hour or two, some of the PTFE is transferred from the surface of the bearing to fill the low regions between the asperities of surface roughness of the journal. Thenceforth, the rubbing action takes place mainly between two PTFE surfaces. During tests that have been carried out over a number of years on bearings of this material, seizure has never taken place even when the surface layer of PTFE has worn away. This is probably because of the action of the PTFE impregnated in the porous bearing metal.

If a high temperature should be developed locally on the surface of the bush due to a high spot causing metal-to-metal contact, the PTFE in the pores in the substrata expands out to the surface to provide additional lubrication, and, during the subsequent cooling, the matrix partially collapses so all the PTFE cannot return into the pores. This collapse also allows the displaced PTFE to spread locally over the surface and at the same time removes the high spot.

Journals of many different materials have been tested in these dry bearings. The materials include both soft and hardened steels, hard anodized aluminium, cast iron and many others. As a result, it has been found that very soft materials should be avoided and alloys with a high copper content are not particularly suitable. The difference in performance obtained as between hard and soft steels is so slight as to be barely significant.

Special measures can be taken to increase the PV factor of the bearings. One, of course, is to improve the finish of the journal. Alternatively, the journal can be coated with an alloy of lead and tin. The melting point of this alloy is 320 deg C, which is 7 deg C below the temperature at which the PTFE softens; as a result, in the event of excessive temperature being developed at a high spot, the lead melts locally and relaxes the load. Coating with this material has been known to double the PV factor of the bearing. Results obtained by coating with tin, which melts at 231 deg C, are not so good, but so far the reason for this has not been explained. It is confidently expected that further developments will enable increased PV values to be obtained for bearings under normal conditions, that is, without plating or specially treating the shaft. Consequently, the figures given in the Table are only valid for units currently in production.

Applications

In general, these bearings are for applications where lubricant is undesirable because it attracts dust or because it may cause disfiguration of the surroundings, such as in the interior of a car. They are also attractive for applications in which, by their use, hand lubrication points can be eliminated or where circumstances make it difficult to retain lubricant in bushes. Since the material has little or no stick-slip tendencies, these dry bearings undoubtedly will be useful in delicate controls or instruments, particularly where they are required to be totally enclosed and run for long periods without attention.

In normal applications, the wall thickness of the bush relative to the journal diameter is an important factor so far as the strength of the bearing is concerned. However, these features are, of course, taken care of in the standard sizes available. The housing eye, too, must have adequate stiffness to prevent distortion under load. The requirements in this respect are no different from those of lubricated plain bearings.

Although this dry bearing has been developed primarily for use with a liquid lubricant, the presence of liquids of almost any kind is advantageous in most cases, since it increases the rate of heat dissipation and may lead to hydrodynamic lubrication conditions in the bearing. It should be remembered that although PTFE is unlikely to be corrosively attacked, the backing material may be affected by certain liquids unless it is suitably protected.

At first sight, it might be surprising that the PV values obtainable with an oscillating load are higher than those with rotating loads or rotating bearings. However, it is thought that this is because the viscosity of PTFE is so high. For instance, it is much greater than that of any of the greases used for chassis lubrication. The next highest PV values are obtained when the load rotates relative to the bush, for example, when the bush is rotating and the shaft stationary. This, of course, is because the bearing material is continually being wiped over the load-carrying area on the shaft so that the whole of the film of the PTFE is effective and any one portion is only loaded once every revolution. When the load is fixed relative to the bush, for example when the bush is stationary and the shaft rotates, only a portion of the PTFE is working and the loading on that portion is continuous.

Fitting instructions

During installation, the bores of these bushes must not be machined in any way, otherwise the film of PTFE will be removed. Care must be taken that the bores are not damaged on assembly, and it is advisable to machine a $\frac{1}{16}$ in long 15 deg chamfer as a lead-in on the end of the shaft. The tolerances on the shaft and the bores should be to B.S. 1916-1953 H6. To facilitate assembly, the housing bores should have a $\frac{1}{32}$ in long, 15 deg chamfer in their ends. During initial running in, a greenish coloured debris may appear on the surface in certain cases. This is not detrimental and, in fact, is an indication of satisfactory operation. Special mandrels and sleeves are recommended for use when assembling the bushes into their housings.

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WELDING RESEARCH

The Metallurgical Aspects of the Work of the British Welding Research Association

WORK of fundamental importance to the science and practice of welding is carried out in the metallurgical laboratories of the British Welding Research Association at 29, Park Crescent, W.1. Although superficially one metallurgical laboratory looks much like another, and all appear to be unspectacular, there is a great deal in the laboratories of this research establishment to interest more careful observers. In fact, there is as much to be seen at the London laboratories as at the Association's Abingdon branch, described in the January 1953 issue of *Automobile Engineer*.

In the London laboratories, the administrative and laboratory staff number about fifty. Their work is of a specialized nature and real progress is being made. Technical knowledge is now so advanced that without specialization in a relatively narrow field it is difficult to make further headway. Only by minute examination of all the fundamentals involved can improvement be made on methods that have already been evolved largely by trial and error.

A most important feature of the work done in the laboratories is its essentially practical character. The problems studied, of course, originate on the bench in welding operations. Although their solution usually involves a study of the fundamentals, the validity of the conclusions reached is finally checked on the bench with the welding equipment.

The Association has a department specially organized to deal with short-term problems of Members. When necessary, visits are paid by personnel of this department as well as by senior research staff to the factories so that the problems can be examined on the spot and the works' staff brought into the discussion. There is no charge for technical advice relating to the application of the results of the work of the British Welding Research Association. Frequently advice given has resulted in savings to Members many times greater than their annual subscription. Private investigations of a more extensive nature are undertaken subject to special financial arrangements.

Reports on the work of the Association are first made available to Members and are confidential. Some of these reports are later published in the Association's journal and elsewhere in the technical press. In the library at the laboratories are all the important works on welding and related subjects, as well as a large number of films and slides, all of which are available on loan to Members. An annual Summer School is organized to give information on the most up-to-date developments

Non-ferrous metals

The work of the non-ferrous metals department of the laboratory is mainly on aluminium and its alloys, but a certain amount is also done on magnesium and a little on titanium. There are two aspects of the work: one is concerned with new welding processes and the other with materials.

At present, four lines of development are being followed. One is the flux-shielded, metal-arc welding of the medium-strength alloy, H10. The second is welding, by the inert-gas shielded processes, of high strength, heat-treatable aluminium alloys; that is, the Duralumin types H14 and H15, and an aluminium-zinc-magnesium alloy, D.T.D.683. Most of this work is on the tungsten-arc process. The third line of development is the investigation of factors affecting the efficiency of the self-adjusting arc process and, in particular, the effect of power source characteristics. This is being carried out in conjunction with the Electrical Research Association. Finally, a study is being made of problems associated with self-adjusting arc welding of certain aluminium alloys, particularly those of the NP 5/6 type.

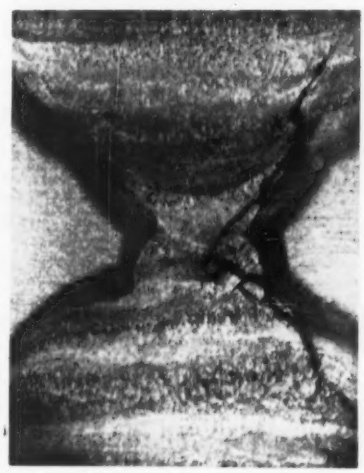


Fig. 1. Slag trapped in this butt weld caused a crack

There are three well-defined stages in the work of each investigation. First, a review is made of published information. This is necessary so that the investigators may gain a comprehensive field of background knowledge and also to avoid doing again work that has already been done elsewhere. The next stage is to make preliminary tests to assist in the planning of the main programme. Finally, detailed investigations are carried out on particular aspects of the problem under consideration.

Metal arc welding of H10 alloy. Hitherto, it has been common practice in industry to fabricate structural units in H10 alloy by means of coated aluminium/5 per cent silicon alloy electrodes, using the double current technique described by Foulkes[1] and Bailey[2]. By this method, thick plates and extrusions can be welded without pre-heat and the weld penetration is greater than is obtained with lower current. However, difficulty has been experienced in practice because cracks frequently occur in the welds, porosity is often excessive and weld strength tends to be low.

Thus, three major metallurgical problems have to be solved: the control and prevention of weld cracking, the control of porosity and the improvement of strength in the weld metal and heat affected zones. These aspects are all affected in some degree by the thermal cycle. Not only does this cycle determine the width of the heat affected zone, and the various conditions of heat-treatment within it, but the rate of cooling affects the amount of constituents retained in solution and the degree and distribution of porosity in the weld metal. The properties of the weld metal also depend on the extent to which the filler alloy is diluted by the metal of the plate being welded.

The Aluminium Development Association research team[3] have shown that H10 alloy is sensitive to hot cracking, and consequently a filler rod of aluminium/5 per cent silicon alloy is recommended. However, when this rod is used, cracking has been experienced with square edge, close butt welds. The reason for this has been found to be that the weld pool contains only a small proportion of filler, which is considerably diluted with the metal of the plate[4]. In fact, a silicon content as low as 1·6 per cent has been observed in the weld metal. Silicon is thought to prevent cracking by reducing the freezing range. Its presence in adequate quantities ensures that when cracks are initiated, there is enough fluid eutectic available to flow into and seal them.

There are two methods of counteracting the dilution. One is to chamfer the edges of the plate, but this increases the cost of production. Another is to use an electrode of higher silicon content. If an electrode containing 10 per cent silicon is used to make butt welds of this type in ¼ in thick plate, the silicon content of the fused zone is approximately 3½ per cent. This still is

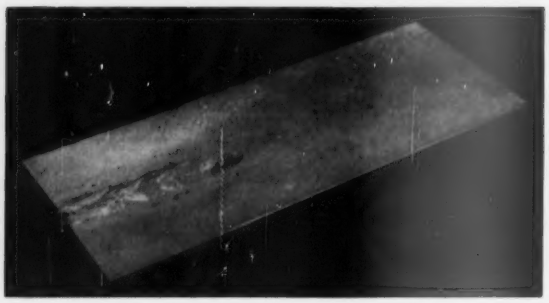


Fig. 2. On the test pieces for assessing the tendency to cracking, the weld bead must not be too wide, as in this illustration

not as high a percentage as is desirable, but there are obvious practical difficulties in increasing the silicon content of the weld pool by using filler rods of an alloy containing an even greater proportion of silicon.

A simple test has been developed to assess the tendency of welds produced with different electrodes to crack. It simulates the square edge, close butt condition, but can be modified to take account of different edge preparations. Briefly, it involves cutting slots of different lengths in plate test-pieces of suitable proportions. The slots are then welded over a standard length from their open ends, Figs. 2, 3, 4 and 5. Contraction of the weld metal is resisted by the strength in bending of the plate on each side of the slot. The fixing moment is applied by the metal of the plate beyond the inner end of the slot, and the tensile load in the weld metal decreases in proportion to the length of the slot, Fig. 5. Therefore, the length of slot that is just adequate to induce cracking after welding is an indication of the suitability of the filler electrode used. Full details of the development of this test and its applications are included in the Report[5].

Apparatus has been constructed for the assessment of cracking tendencies in terms of the distance of rigid supports from the line of weld. If support clamps, or any other heavy section of metal, are attached close to a butt weld between two plates, the heat flow characteristics are changed. Moreover, the strain due to weld bead contraction is taken by a small width of plate and therefore the stresses induced are high. Thus, the closer the support to the line of weld, the greater is the tendency for cracks to develop.

The apparatus comprises two pairs of clamping bars, one pair for each test plate, held by a hydraulic jack on to a base plate. On the base plate, serrations are machined parallel to the clamping bars which in turn are, of course, parallel to the butt joint between the test pieces. Serrations on the under-surface of the lower bar of each pair register in those on the base plate. A noteworthy feature of this apparatus is that adjustment to the distance between the support clamps can be effected rapidly and easily, and that movement cannot take place once the adjustment has been made and the clamping pressure applied by the hydraulic jack.

Simplified methods for the calculation of temperature gradients in and around welds have been developed[6]. The effect of plate size on temperature distribution has been studied and calculations show that to give a reasonable approximation to the thermal conditions in an infinite plate, weld test-plates should have a half width of not less than ten melted widths. These mathematical relationships are being checked by practical tests, and additional information will be obtained in due course.

Welding of high strength, heat treatable alloys. Most of the work on this subject has been confined to the tungsten-arc welding of the Duralumin type alloys H14 and H15, and an aluminium-zinc-magnesium-copper alloy. The thicknesses involved in the tests range from 12 S.W.G. to $\frac{1}{2}$ in. Published literature[7] indicates that the weld strength for these alloys is currently about 50 per cent that of the heat treated plate, and weld cracking is prevalent. From their survey of this literature, the Association concluded that some improvement could be obtained by refining the grain of the weld and by the use of aluminium-magnesium alloy fillers.

Preliminary tests indicated that the cracking experienced is not so serious as reported in the literature. Joint efficiencies of 60 per cent were readily obtained with a number of filler materials used on 12 S.W.G. and $\frac{1}{4}$ in thick sheets of these alloys, and efficiencies of over 90 per cent have been obtained after heat treatment. The highest tensile efficiencies were generally experienced with a filler of the same material as the plate, but there was some evidence of cracking when these fillers were used.

Subsequent investigations have been directed towards the development of new filler alloys by systematic investigation of selected alloy systems. They have also been aimed at the assessment of the dilution effect and the distribution of parent and filler metal in the weld beads. Further work has been done on grain refinement by the use of suitable alloy additions to the filler metal. Research has also been undertaken to find a suitable cracking test.

As a result of the work so far completed, as-welded strengths of 70 per cent or more have been obtained with thin gauge material, whereas only 60 per cent is obtainable with the earlier techniques. When the investigations are complete, a Report will be issued on the cracking resistance of the welds. The investigations on dilution effects have made possible the selection of suitable filler compositions for use in welding these high strength alloys. Some tests have been made on the tungsten-arc welding of an aluminium-copper-cadmium alloy.

Electrical characteristics of the self-adjusting arc process. In this process, the heat source is an arc between the plate and a bare wire electrode mechanically fed at a pre-set constant speed through a welding gun. An argon shield is provided to protect the weld pool from oxidation. The process has a number of advantages. One is that manual welding can be effected at high speed and in almost any position. Also, arc length is closely controlled, since

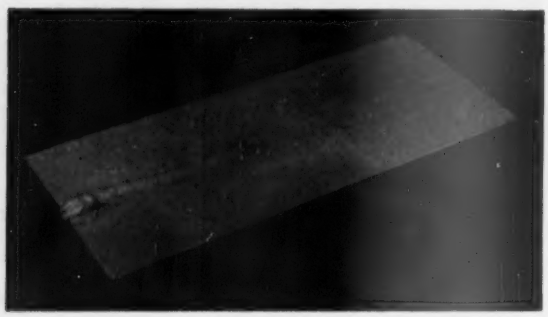


Fig. 3. In this short-slotted test piece the weld is not satisfactory, because the build-up of the bead at the outer end of the slot is too heavy

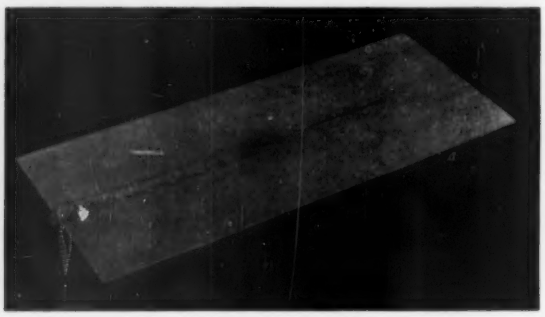


Fig. 4. This test piece is unsatisfactory because the weld bead is too high throughout its length and so gives locally a false indication of the strength of the joint

it is determined by properties inherent in the arc and characteristic of the power source.

An investigation into the effect of the source characteristic on self-adjustment has shown that a marked improvement occurs with power sources having a flat output characteristic and an open circuit voltage approaching that of the arc. With this type of source, the presetting of the welding conditions is simplified. Moreover, the risk of serious delays, due to *burn-backs*, in production is minimized. Another noteworthy feature of power sources with this characteristic is the exceptionally small amount of drift in welding conditions experienced. With generators that have an open circuit voltage that is high relative to the arc voltage, drift invariably occurs as the windings heat up. In this connection, a special unit has been developed to correct for drift when conventional power sources are employed. A device for preventing burn-backs has also been made.

Preliminary investigations disclosed the need for a special welding head for research purposes, since accurate control of welding variables was required. This equipment has now been constructed, Fig. 7, and a comprehensive study of arc characteristics is under way. Work in progress includes a study of the overall relationships between arc voltage, arc length, welding current and electrode burn-off rate. The mode of metal transfer in the arc is also being examined by high speed photography. All these investigations are being carried out in close co-operation with the Electrical Research Association.

Self-adjusting arc welding of aluminium-magnesium alloys. This work is concerned in particular with N 5/6 alloys, and the general plan is as follows. The first stage has been the development of a standard method for assessing porosity, so that the results of the investigation can be readily recorded and compared. Next, equipment has been constructed for the determination, by hot extraction and tin fusion methods of analysis, of the proportion of hydrogen in plate and wire materials. The effects of surface treatment and composition of plate and filler wire, rate of cooling, and porosity also had to be studied.

Work on the control of weld porosity is also proceeding. In fact the first stage has been completed. The results obtained at this stage represent a useful, practical advance in that it is now possible to express in reasonably accurate terms the degree of porosity observed in a weld. As a result, it is now possible to compare and correlate estimates of weld porosity reported by different workers, even in widely separated sections of industry, provided the methods advocated by the Research Association are adopted.

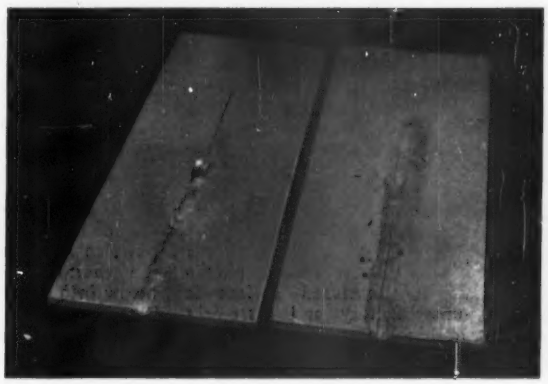


Fig. 5. This illustrates how the tension across the weld bead in a short slot is sufficient to cause cracking, whereas in a long slot it is not

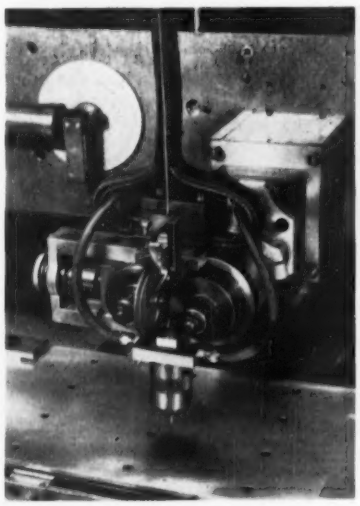


Fig. 7. Experimental welding head developed by The Electrical Research Association for the self-adjusting arc process

The B.W.R.A. method for the determination of porosity consists essentially of taking a cross section of the weld, polishing it to reveal the pores, and observing it through a microscope. The main problem is to determine the relationship between the numbers and sizes of the pores thus observed two-dimensionally and those that exist in three dimensions. It was thought that the work would be further complicated by the fact that a plane through the weld does not necessarily cut diametrically through all the pores, so that size determination might be difficult. However, in practice, it has been found that the pores revealed by polishing are, to all practical intents and purposes, sectioned on their diameters. This is because the polishing action, instead of sectioning through the minute spherical voids as soon as they break through the plane of the polished surface, causes the metal immediately above them to deflect into the void until finally it breaks away only when the cavity is of almost hemispherical form. Further polishing beyond the level of the plane containing the centre of the void tends to fill the cavity with particles of metal, so that it disappears altogether.

The severity of porosity is defined by two code numbers and a letter. These are obtained by examination of the microsection and by reference to tables prepared by the Association. One of the numbers represents the size of the pores, the second the frequency and the letter specifies the distribution, that is, it indicates the location of the porosity within the weld bead. From the code specification, the number of pores per unit volume, the percentage of voids, and hence the density, can be estimated with the aid of the tables. Densities calculated in this way have shown good correlation with measured densities.

There are, of course, other methods of observing porosity, but the recording of results is difficult and no one method is entirely satisfactory itself. Radiographic examination has limitations in

Fig. 6. Cross section of a weld bead into which a plated thermocouple has been inserted

Fig. 8. A cross section of a weld to which a spring-loaded thermocouple has been applied

that fine pores are frequently unobserved, the distribution of porosity is difficult to judge and the results cannot be recorded except by reference to arbitrarily chosen, standard radiographs. A record of the percentage of voids can be obtained from density measurement, but no indication of the size or distribution of the pores is given by this method.

Examination of fractures is a quick and useful method, but again, the results are difficult to record; photography of the fractured surface is usually unsatisfactory and extremely difficult at high magnification. Microsections are easily photographed, and when viewed in conjunction with radiographs a fairly complete picture of the sizes and distribution of pores is obtained. However, hitherto, there has been no generally accepted method of recording numerically the sizes and distribution.

Weld pool temperature measurement. Practical difficulties in the measurement of weld pool temperatures have been largely overcome and work on the effect of the thermal cycle on the distribution and amount of porosity is making good progress. Weld pool temperature measurement is often difficult because the arc may blow off the welded ends of the thermocouples. However, this is not serious if the ends of the two wires are wetted by the molten metal to complete the circuit. A plating technique has been developed to ensure that the ends will wet, and promising results have been obtained, Fig. 6.

For temperature measurement during metal-arc welding, the Association has also developed a method in which the thermocouple is inserted from below into the weld pool as it forms. The thermocouple is spring-loaded, so that, as the metal between it and the weld pool becomes soft, it is pushed through into the pool, Figs. 8 and 13. By the time the break-through occurs, the welding arc has passed the thermocouple so that it does not blow off the end.

Recording of fluctuations of temperature is important since they have a marked effect on weld quality. For instance, rapid welding restricts the heat affected zone, and thereby tends to increase the strength of the joint. On the other hand, it does not allow hydrogen time to escape and this increases the tendency to porosity. In fact, the problem of the control of porosity is not only one of reducing the quantity of hydrogen introduced, but also one of allowing the gas time to escape. An oscilloscope can be used in conjunction with a thermocouple for temperature measurement and gives instantaneous response, but the problem of the lag in the thermocouple still has to be overcome. Records of the relatively rapid changes in temperature indicated by the oscilloscope, as well as by sensitive millivoltmeters, are made by photographing them, together with a stop watch, with a ciné camera. The films are viewed with a Zeiss Moviscop.

Fig. 10. Apparatus for hydrogen determination by the vacuum heating method

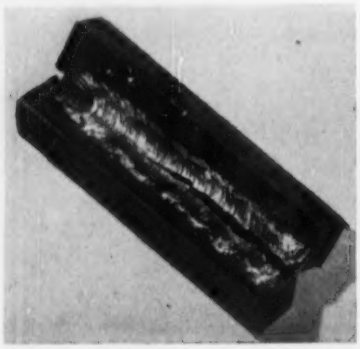


Fig. 11. Hot cracks tend to open on cooling; in this test piece, the crack has been opened further by rotating one of the plates relative to the other about an axis through the weld bead

Ferrous metals

The investigations of the ferrous metals department are concerned more with materials than processes, and one object is to extend the range of steels that can be welded satisfactorily. That so much attention is devoted to materials is because the main processes for the welding of ferrous metals have been well established for many years. However, one or two new processes are under investigation, notably welding with self-adjusting arc equipment.

The appearance of transverse cracks in welded joints is one subject that is being studied. Many of the cracking troubles experienced in the metal-arc welding of alloy steels appear to be caused by hydrogen. This gas is produced by dissociation of water vapour at very high temperatures. It may be evolved from moisture in the electrode coating, and particularly from water combined with the sodium silicate in the coating. Therefore, the first stage is to take every precaution to ensure that the rods are supplied in a clean, dry, state. Investigations are being carried out to determine the effect of the rates of welding on gas inclusion. When the flame welding or argon shielded processes are employed, dryness of the gas is of importance.

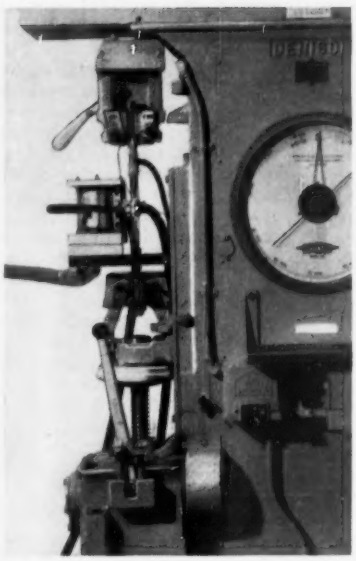


Fig. 9. A 6kVA heater is used in conjunction with a 5½ ton Denison machine for hot tensile tests

Hitherto, it has been thought that all hydrogen is driven off at a temperature of about 800 deg C. However, there is some doubt about this. It is now thought that, at this temperature, some of the gas may be dissolved in inclusions and retained. An investigation on this subject is shortly to be carried out.

At present, hydrogen determination is being effected by vacuum heating, Fig. 10, but the work to be done in future will involve vacuum fusion. A

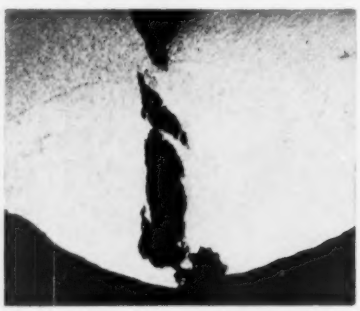


Fig. 12. Photomicrograph of the crack in the weld bead of the specimen illustrated in Fig. 11

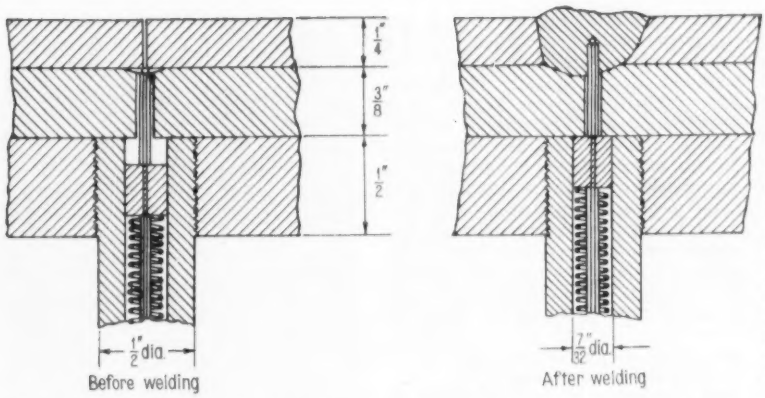
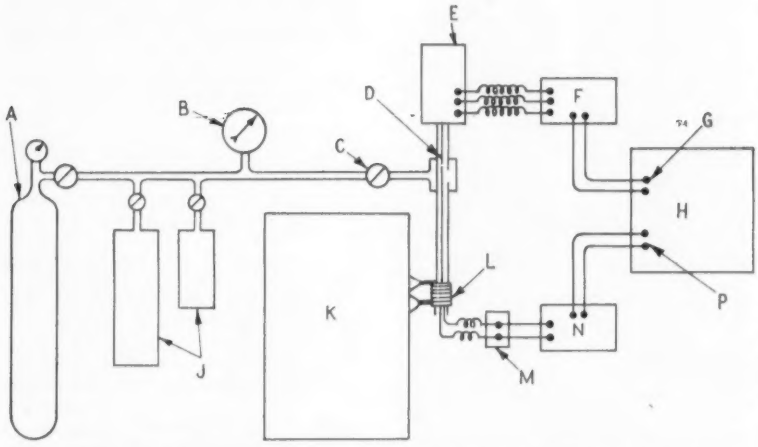


Fig. 13. Spring-loaded thermocouple arrangement for weld pool temperature measurement



A—Gas cylinder. B—Pressure gauge. C—Gas quench tap. D—Push rod from specimen. E—Dilatometer. F—Bridge circuit. G—Dilation controls the movement of first pen. The second pen moves at a constant speed and draws the cooling curve. H—Function plotter. J—Gas reservoirs. K—High frequency heating set. L—Specimen in centre of heating coil. M—Thermocouple cold junction. N—H.F. filter. P—Chart movement.

Fig. 14. Diagrammatic illustration of apparatus for producing dilation and cooling curves

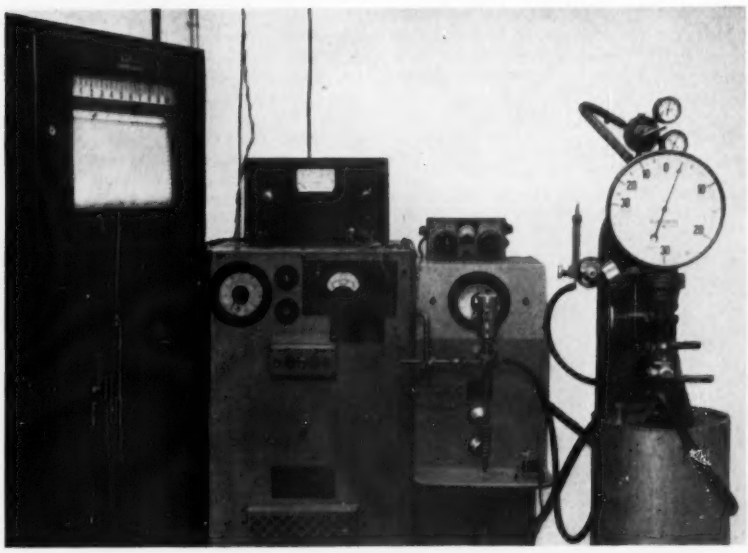


Fig. 15. Apparatus for producing dilation and cooling curves

6 kVA induction heater has recently been acquired for these tests. This heater, in conjunction with a 5½ ton capacity Denison machine, is also being used for hot tensile tests of specimens cut from the weld bead, Fig. 9. During the test, the specimen is shrouded in argon to prevent oxidation. The object of this work is a comprehensive investigation of the hot cracking phenomenon in mild steel welds. A hot cracking test, now known as the double-fillet test, has been developed as a result of the research work. This has already proved of some value in the investigation of hot cracking and has been of use to manufacturers in the development of electrodes.

Recently, attention has been paid to the Murex hot-crack machine to see whether it can be used for both a workshop test and research work. In this connection, over two hundred tests have been carried out and promising results have been obtained. The principle of the machine is as follows. Two small plates, held edge-on in rigid clamps, are fillet welded and during welding, one of the clamps is rotated a few degrees about an axis coincident with the joint, so as to open out the weld. This places the solidifying weld metal under severe restraint, and hot cracks, if they form, tend to be opened out, and fractured surfaces that are characteristically blued by oxidation are displayed. A severely cracked weld is shown in Fig. 11; in this case most of the plate has been sawn away to permit the cutting of a cross section of the weld. A photomicrograph of this section is shown in Fig. 12.

During some earlier work, a series of low alloy steels of widely varying composition was examined for weldability (resistance to hard-zone cracking, Fig. 16) and mechanical properties. Further tests[8] were made on two selected steels produced in the form of two ton casts. In this form, both were found to have good mechanical strength and were completely weldable with rutile-coated electrodes. The effect of slight variations of their composition was examined, and it was shown that carbon content had an over-riding influence on both yield strength and weldability. Investigations were also made into the effect of substituting vanadium for molybdenum in these alloys[9,10]. With two steel compositions, when vanadium was substituted for molybdenum, but in half the quantity, good weldability and mechanical properties were retained.

Various tests, suitable for studying liability to hard-zone cracking, were examined for rate of cooling and restraint; and, as a result, basic data were provided which made the Controlled Thermal Severity (C.T.S.) test possible[11]. The problem of hard-zone cracking has now been largely elucidated in terms of hydrogen content, steel composition and rate of cooling. In addition, it has been shown that external restraint, previously thought to have an important influence, is not necessarily the cause of the initiation

Fig. 16. Micro-crack in the heat affected zone of a weld in low alloy steel. 97 magnification

of hard-zone cracking. The effect of rate of cooling in the region of 300 deg C has been shown to be critical with respect to hard-zone cracking. This relationship between cracking and rate of cooling was established using weldability tests and also standard types of structural joint.

The Laboratories have now developed a new method for determination of the weldability of alloy steels[12,13]. Small tubular test pieces of the metal to be welded, about ¼ in long by ¼ in outside diameter, are employed. Manufacturers who supply materials for these test pieces together with detailed information, such as the number and thickness of the members to be welded together at one joint, etc., are given by the Association all the information necessary to ensure satisfactory welding.

This information includes the type of electrode needed, the thermal cycle, size of weld required, and whether pre-heating is desirable. It is obtained by taking dilatometer measurements while heating the test piece with a 1 kVA induction heater and then cooling it rapidly to simulate the welding process. Cooling is effected by passing an argon gas stream over the specimen. In fact, the reason why a tubular test piece is employed is that the gas can be passed through the tube as well as along the length of its outer periphery to give a rapid and uniform rate of cooling.

The dilatometer measurements give an indication of the changes that take place in the metal at different temperatures. The temperature at which the change from an austenitic to a martensitic structure takes place determines the liability to cracking. This temperature is affected by the rate of cooling, hydrogen content and the alloy steel composition.

The dilatometer at present used is an arrangement of wire strain gauges, which measures the expansion and contraction of the specimen, Fig. 14. These dimensional changes are recorded by a special, Honeywell-Brown chart recorder known as a *function plotter*. The method of employment of the recorder is unusual. Instead of rotating the chart drum at a constant speed to give a time base, it is made to give a temperature base: that is, it rotates in one direction as the temperature increases and back in the other direction as the specimen is cooled again. Two pens are used: one gives the time base and the other the dilatometer reading. Thus, two curves are drawn simultaneously during the rapid heating and cooling of the specimen. A number of pairs of curves are prepared, each for a different cooling rate, and from them the weldability of the steel can be deduced. The apparatus is illustrated in Fig. 15.

A study is also being made of fissuring in weld metal, Fig. 17. This is the fine cracking that often occurs in rapidly cooled welds. In the research, good use is being made of two new microscopes that have recently been acquired by the Association. Both are Reichert machines obtained through the Shandon Scientific Co., London, S.W.7. One is the Zetopan binocular type instrument and the other is the M.E.A., universal microscope, which is built on an optical bench. A camera attachment is also incorporated for use with the microscope on the optical bench. The other accessories with the bench type instrument include phase-contrast, polarizing and micro-hardness testing equipment. By using this equipment, the Laboratories are now able to carry out hardness tests with loads as low as 2 gm.

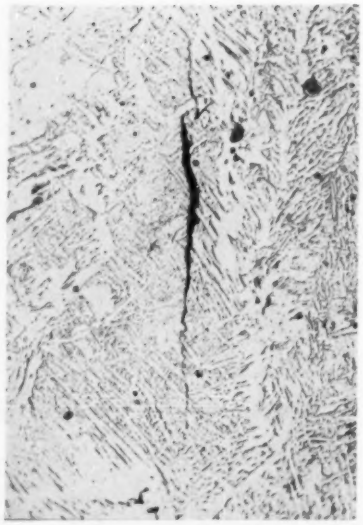


Fig. 17. Fissure caused by rapid cooling of a weld made with a Class 3 electrode 315 magnification

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Thred-gard

A PRODUCT, Thred-gard, recently introduced to this country, will solve the problems arising from seizing and galling of threaded connections that are subjected to prolonged exposure to extreme heat. It is a special compound which, when painted on the surface of the bolt or stud before it is fitted, protects the thread against the welding action.

Thred-gard is a non-drip and non-hardening substance, manufactured by Crane Packing Ltd., of Slough, Bucks. It lubricates and protects the surfaces of studs, bolts, plugs and similar fittings. When it is applied wrench torque is greatly reduced and fittings can be drawn up to a greater degree of tightness. At operating temperatures up to 1200 deg F, seizing and galling are completely prevented and the threaded connections can be easily disassembled.

Other applications include protection for thread-cutting dies and taps, broaching and spinning tools, wire drawing dies and lathe centres.

BIRMETALS FILZALL

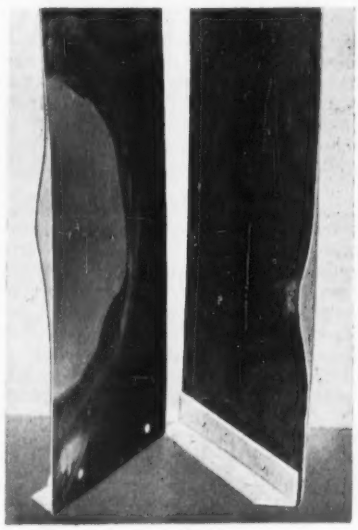
A Universally Applicable Filling Compound

THIS new filler material was specifically developed to cheapen and facilitate the repair of motor vehicle body panels, whether of steel or light alloy. It is finding increasing application in production, however, for preparing surfaces prior to painting or finishing. In passenger and commercial vehicle bodywork it serves to fill interstices in interior or exterior panelling and, similarly, is used in the final preparation of marine hulls and aircraft skins to conceal rivet or screw heads and to smooth welded joints and seams. Superficial defects in castings of any metal can be filled and even surfaces of wood, stone or cement can be treated. It will adhere to glass.

Produced by Birmetals Ltd., Quinton Birmingham, "Filzall" is a compound of a metallic powder and thermoplastic synthetic resins and is the subject of a Patent application, No. 5678/54. It is completely inert, has no chemical affinity for other metals, and does not penetrate the grain boundaries of aluminium alloys; such penetration could cause cracking and the eventual breakdown of a repair. This characteristic can be of some value in mixed constructions as "Filzall" forms an effective dielectric between dissimilar metals and will thus prevent electrolytic corrosion.

In making comparisons with fillers hitherto available for bodywork repairs, it must be emphasized that "Filzall" is not a solder and should not be used for joining metals. When being applied it requires no flux whatsoever and thus can be used without risk of damaging interior trim or upholstery. Neither is it a so-called plastic metal which sets hard upon the evaporation of solvents. There are not deleterious fumes or odours objectionable to the operator and no long waiting period before the surface can be finished and painting commenced. Only a modest heat—from 150 to 200 deg C—is required to render "Filzall" plastic. It follows that there is no risk of distorting a panel or of scorching closely adjacent upholstery. It can safely be used, with an indirectly heated paddle of course, near to or on a fuel tank. Small holes in a fuel tank may be stopped with "Filzall" as the resins are insoluble in petrol.

An important feature is that, whatever the depth of the indentation, the depression in the panel can be filled directly in a single operation and built up above the panel contour. Since it is never melted to the fluid state it is just as easy to apply on a vertical or even an inverted surface. There is no necessity to apply in thin layers which must each be allowed to dry out, as with plastic metals, and no difficulty in retaining it, as with liquified solder. On solidifying, which requires only a few seconds, there is no shrinkage and consequent sinking at the centre of the filler. Thus it becomes practical to effect on the vehicle many repairs that otherwise would require the detachment of the panel for treatment on the bench. The application does not call for skilled labour.

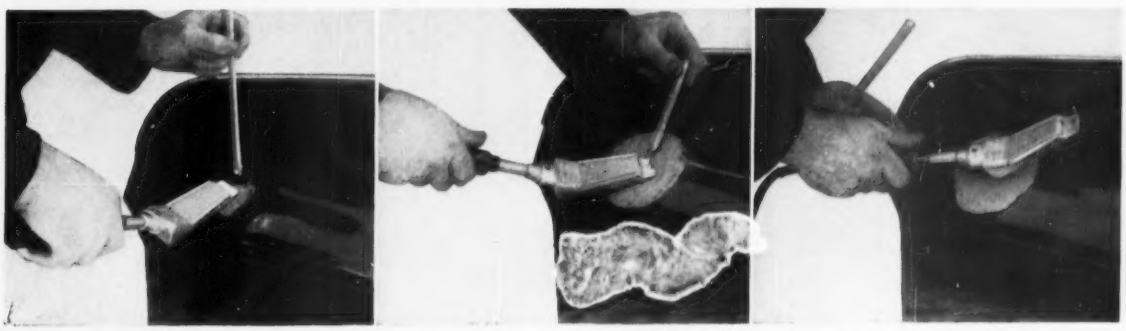


Sections of repaired panels showing deep filling and perfect feather edge

As the compound will bridge only small apertures and has little strength, a badly perforated panel should be roughly sealed by first welding in a plate. In the case of a tear or a split either a bridge piece or ties at intervals should be secured by welding prior to filling.

The ability to fill a deep dent in a panel without first beating out the depression from the rear is of special value in the case of damage to one of the panels of a double-panelled and welded door. There is no need to cut, and subsequently patch, an access aperture in the other panel. The weight of a deep filling is not a factor of importance since "Filzall" has a low density; actually it is only about 25 per cent of that for a metal solder. There would appear to be no risk of cracking or loss of adhesion in service. A strip cut from a steel panel with a substantial filling has been vibrated at the rate of 100 reversals per second over a deflection of 0·25 in. Subjected to a test continued to over 100 million reversals it yielded no evidence of breakdown.

Providing the special electrically heated paddle is used there is no need to remove the paint before making a filling, but the compound will not adhere to rust. First the damaged area is mopped with a petrol-soaked rag to remove grease and dirt and then the painted surface is roughened with a sheet of coarse glass paper. With the paddle at working temperature a little of the compound is melted off the stick and spread thinly over the centre of the area, as in tinning. Further compound is melted and applied until



Filling an indentation on a substantially vertical surface. Left to right: applying initial layer to centre of damaged area, building up and spreading the fill, smoothing off preparatory to finishing

the depression is slightly overfilled and spread over the margins. It is then smoothed over with the heel of the paddle to minimize the amount of dressing required.

The filling is then roughly shaped to contour with a rasp or a "Dreadnought" milling file. Should it then be found that it does not clean up to contour there is no difficulty in applying more compound. Finally it is finished to a smooth surface and a perfect feather edge with a sanding tool. On this the sanding disc is reversed and the canvas back is used lightly to create sufficient heat by friction to plasticize the surface and produce a smooth glaze. Painting can be commenced immediately; the first two coats should be mist coats. The filler will withstand stoving provided a temperature of 130 deg C is not exceeded.

An alternative method is to use a blowlamp or a torch, when a metal solder technique should be followed. It will, of course, be necessary to remove the paint and to heat the panel. Wooden paddles, protected by soaking in a special lubricant supplied by the firm, are employed to spread the compound when a torch is used.

"Filzall" is injection-moulded into ⅛ in hexagon sticks with a standard length of 12 in and weighing 2 oz. They are packed in cartons of 12 or 50 sticks and do not deteriorate in storage.

AUTOMATIC MICRO-SIZING

Developments in Controls for Centreless Grinding

HITHERTO, the methods used for fine feed adjustment of the control wheel (or grinding wheel) on centreless grinding machines for the correct sizing of the work have all depended upon the rotation and adjustment of a graduated index wheel. This is a process that demands a certain degree of visual aptitude combined with manual dexterity, in much the same way as is called for in setting a micrometer or a slide rule. It is an aptitude that is not always possessed by the operator, especially an unskilled one.

There will therefore be considerable interest in the push-button micro-sizer recently developed by Arthur Scrivener Ltd., Birmingham, 24. This device is an hydraulically operated mechanism so arranged that on the pressure of an operating button, the fine feed shaft of the machine is rotated a predetermined amount. The actual amount that the wheelhead is fed forward by each depression of the push-button can be selected at will by the rotation of a selector knob at the opposite end of the device. The knob gives a range of five increments varying from 0·0001 in to 0·0005 in. This device is particularly useful in shops where there are long runs of work to close limits and where male or female unskilled labour is employed to operate the centreless grinders. If when the work is gauged, it is found to be growing above the upper tolerance limit, the operator has merely to press the button and the wheel is advanced the predetermined amount. This hand-operated device is shown in the accompanying illustrations.

Continuous gauging

In addition to the hand-operated type, there is a second type that extends the principle to electrical operation of the micro-sizer under the control of accurate pneumatic measuring equipment. This type is applicable for continuous automatic control of size on through-feed work. It has been developed in conjunction with the Sigma Instrument Co. Ltd. and uses their twin-jet ring gauge through which the work leaving the machine is continuously fed.

The ring gauge has two measuring jets and a monitoring jet, which has the purpose of ensuring that the measuring jets function only when the work is actually in through the gauge. Consequently, the intermittent gaps caused by the passage of the ends of the workpieces through the gauge have no effect upon the accurate recording of size. A controller switch under the influence of the measuring jets is arranged to switch power impulses to the micro-sizer when the size of the work being gauged reaches the upper tolerance limit.

A third type has been developed for application to plunge-grinding operations when it is not possible for the work to pass continuously through a ring gauge. Equipment similar to that for the second type is used, but instead of a ring gauge being fitted on the outgoing side of the machine, a suitable gauging head is mounted in a convenient position near the operator. As the work is ejected from the machine, the operator places it in the head where it is automatically checked for size. If it is above the upper tolerance limit, the micro-sizer is automatically operated to advance the wheels by the predetermined amount.

In the case of a fully automatic machine arranged for long runs on a plunger ground component, it is sometimes possible for the feeding gear that places the piece between the wheels to be arranged to transfer the work to the measuring instrument. This makes the grinding operation and sizing fully automatic.

These developments, particularly when used on multi-head transfer grinders, make possible the completely automatic control of the grinding operation, leaving only the frequency of the wheel-truing operation to be determined. This can often be arranged on a fixed time basis, providing control is maintained over the amount of variation in stock removal with which the machines have to deal.

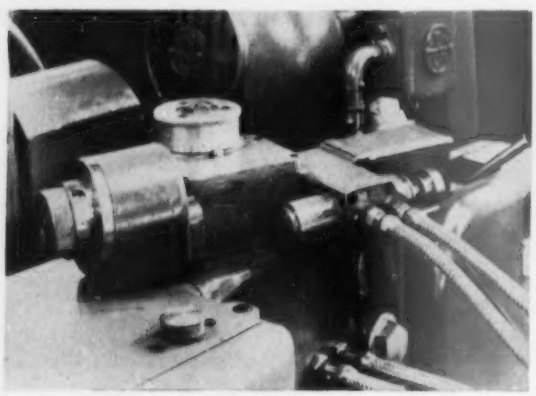


Fig. 1. Micro-sizer from selector end

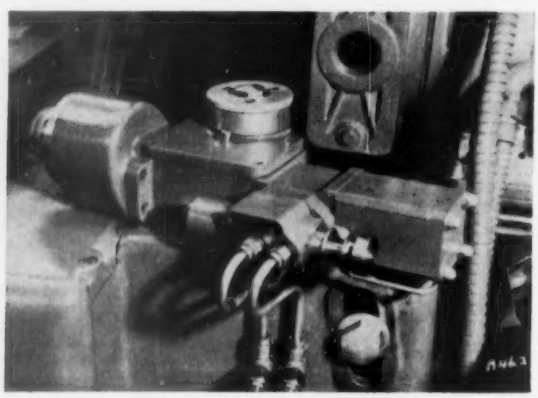


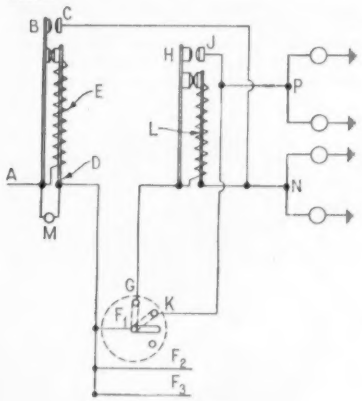
Fig. 2. Instrument from push-button end

CURRENT PATENTS

A Review of Recent Automobile Specifications

Safety switching of lighting circuits

UNLESS each item of electrical equipment on a vehicle is furnished with a separate safety fuse, any short circuit that may occur constitutes a fire hazard and by night a lighting failure may result in a serious accident. By this invention a failure of the headlight circuit switches on the dim light circuit and *vice versa*. Since neither circuit can be switched on at the same time as the other a short circuit can only occur on the one or the other.



No. 707316

A lead A connects the battery to a resilient strip carrying at its free end a contact stud B. This contact is held out of engagement with contact C, connected to the dim-light circuit, by a bimetallic strip D heated by a resistance E. Current flows from strip D to the general system through lines F_1, F_2 and F_3 and line F_4 leads to a switch that selectively controls head, dim, and side lights. Stud G of the switch is connected to a second resilient strip carrying contact H similarly held out of engagement with contact J, connected to the headlight circuit and stud K of the switch, by bimetallic strip L. A tell-tale light M may be provided across the first automatic switch.

By day or by night while the dim lights are off, a short circuit occurring on one of the power-consuming components, including the headlights, will result in the heating of the first automatic switch and deflection of the bimetallic strip allows contacts B and C to engage and switch in the dim lights N. The tell-tale lamp M, being earthed, will also light up.

If a short-circuit occurs at night while the dim lights are on, the second and smaller automatic switch is heated and contact is established by studs H and J to switch on the headlights P. *Patent No.* 707316. *Scintex* (*France*).

Integral construction

FRONT and rear axle assemblies, one embodying the engine and transmission, are arranged for easy attachment to the complete body-frame which is lowered on to them for the final assembly. In the example, the frame comprises longitudinals A braced by cross members B and side pillars C in the form of closed arches. It is completed by braced extensions D and E, at the front and rear respectively, to give a relatively rigid structure resistant to twisting. The skin F is attached by welding.

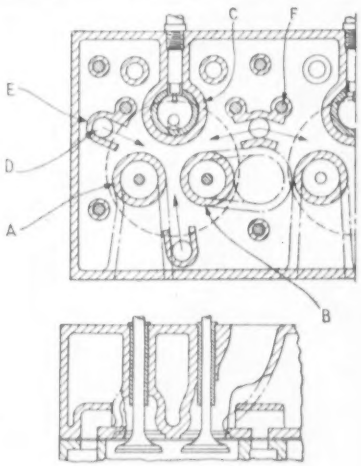
At the front an auxiliary frame G carries the wheel suspension units H (superimposed links and helical springs with shock absorbers), the engine J, change speed gear K and the differential gearing. Other components such as the radiator, battery, and steering gear may also be mounted on the auxiliary frame, which is connected to the main structure at points L and M. Preferably the connections and also the engine and gear mountings are rubber-cushioned.

The rear axle is pivotally connected to the main structure by radius links N and helical suspension springs are interposed between the links and brackets P attached to frame members A. In the case of a rear-engined vehicle, engine, transmission and suspension units would preferably all be mounted on an auxiliary frame. *Patent No.* 706025. *Daimler-Benz A.G.* (*Germany*).

Coolant flow in cylinder heads

IN the cylinder head of a diesel engine of the precombustion chamber type, the valve passages and the combustion chamber are so arranged that the intervening channels conduct coolant radially inwards towards a common point approximately above the cylinder axis. Streams of coolant from the cylinder jacket are directed into the channels by deflector ducts formed in the head casting over the communicating orifices. The coolant flows with increased velocity over the congested centre of the head, preventing the accumulation of deposits and ensuring uniformity of cooling effect. Valves are slightly recessed into the head to locate the seatings more effectively in relation to the coolant.

A constructional example shows a cylinder head having an exhaust passage A opening to the side, an inlet passage B opening to the top, and a precombustion chamber C. Over the transfer orifices D are cast angled deflectors E which direct the coolant horizontally and radially into the channels between parts A, B and C. The three orifices D, and corresponding openings for other cylinders, may constitute the only connections if a specially high delivery velocity is required, but further orifices, without deflectors, may be provided to facilitate the flow. Enclosures for the holding-down bolts F are separate from the walls of A, B and

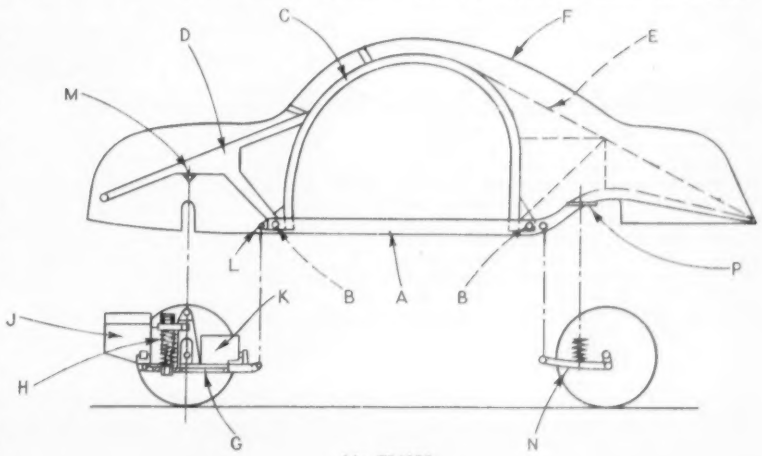


No. 706974

C but may be formed together with deflectors E.

It will be noted that the valves are relatively small in diameter and that the cross sections of the valve passages increase towards the exterior of the head. This feature enables large coolant channels to be provided, but it is also claimed as an advantage as it increases the air and gas velocities at the throats of the inlet and exhaust valves respectively.

The invention is applicable to all types of diesel engines and also to petrol engines. *Patent No.* 706974. *Daimler-Benz A.G.*

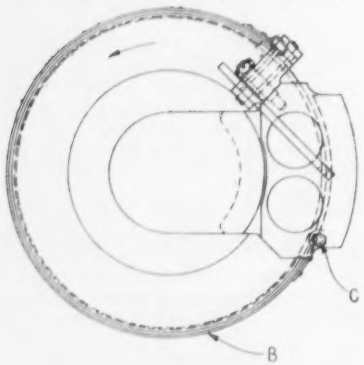


No. 706025

Combined disc brake and hand brake

AN independent, mechanically operated hand brake is arranged in conjunction with a hydraulically operated, straddle-type, disc brake. The disc is formed at its periphery with a groove A of rectangular section to accommodate a thin flexible metal band B lined with friction material. One end of this band is anchored on a pin C attached to the straddle yoke, while the other end is looped and engaged by one arm of an operating bell-crank lever D pivoted on a bracket E secured to the yoke. The friction band embraces about three-quarters of the periphery of the disc.

A number of alternative constructions are suggested. The disc may be formed with a peripheral vee-groove and the



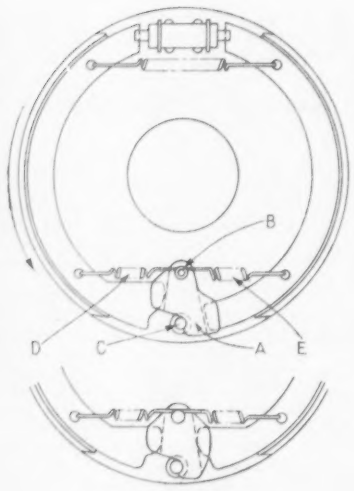
No. 706640

band of friction material be of complementary section. Instead of co-operating with the disc, the friction band may be associated with the cylindrical hub element of the disc. With a disc having an ungrooved periphery, a friction-faced shoe pivoted on the yoke may be actuated by a cam on the operating lever spindle. *Patent No.* 706640. *Dunlop Rubber Co. Ltd., and H. J. Butler.*

Servo brake

THE shoes of this brake are expanded by a single hydraulic actuation cylinder and their free ends are slidably supported on a lever A pivoted at B on the brake plate. Both operative faces of the lever extend radially in relation to the axis of the drum so that the return springs exercise a centering effect on the shoes. When the brake is inoperative, lever A abuts a centering bolt C, and thus a servo action is obtained only when the vehicle is travelling forwards. Of the two return springs D and E, anchored on pivot stud B, spring E on the secondary shoe is much the stronger in order to exert a damping action on the servo force transmitted from the primary shoe.

To obtain the maximum servo force, engagement of the shoe ends with the lever A is arranged at the same radial



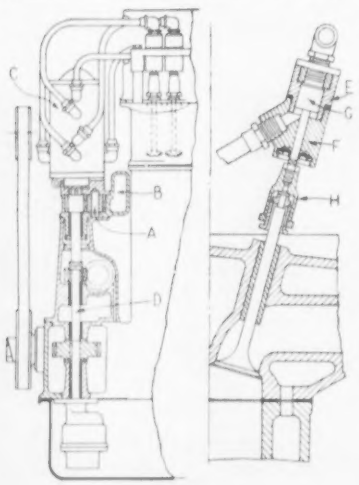
No. 707547

distance from pivot B, as shown in the detail sketch, but preferably the force is transmitted through the primary shoe engaging on a shorter lever arm than the secondary shoe. *Patent No.* 707547. *A. Teves, H. Teves and E. A. Teves (Germany).*

Fluid-actuated valves

CAMS and springs are eliminated in this method of valve operation by fluid pressure, in the example hydraulic but alternatively pneumatic. Fluid pressure of a liquid, preferably oil, is provided by a pump A which draws from a small reservoir B and delivers to a rotary distributor C that is the subject of another patent, No. 701963. Both pump and distributor are driven directly from the vertical half-speed shaft D. From the distributor the fluid is piped to each end of a small cylinder E supported on a block F secured to the cylinder head and located over the valve stem. In the cylinder is reciprocable a piston G, the rod of which passes through the block and a seal and is attached by a self-aligning and adjusting device H to the valve stem.

Fluid is applied to, and relieved from, each side of the piston to lift and close positively the engine valve. A spring-



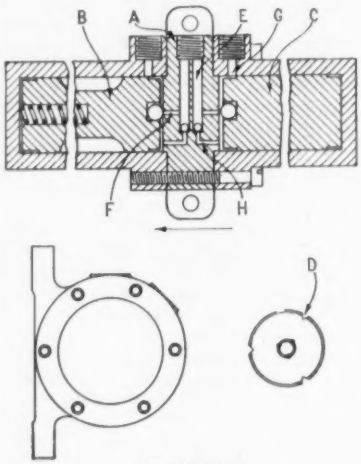
No. 707131

loaded valve, controlling a by-pass from the delivery to the admission side of the pump, may be regulated automatically to vary the operating fluid pressure in relation to the speed or load of the engine and thus modify the valve lift characteristics. *Patent No.* 707131. *J. I. Owens, W. Brammer and D. J. R. Daniel.*

Automatic brake control

IN four-wheel braking systems, of the liquid-pressure, air-pressure or vacuum type, this device will automatically vary the ratio of the actuating force at the rear brakes to that applied at the front brakes in response to change in the rate of deceleration of the vehicle. Usually, the ratio will be unity at a predetermined value of the deceleration (other than zero value); greater than unity below the predetermined value; and less than unity above the predetermined value.

The valve illustrated, for a hydraulic system, comprises a thick disc-shaped body A which is attached to the chassis frame with its axis parallel to the direction of travel of the vehicle. On the forward and rear faces of the body are



No. 707372

spigoted closed cylinders in which are freely slidable masses B and C respectively. Each mass is longitudinally grooved on its periphery, as at D, to allow fluid to pass from end to end of the cylinder. Fluid from the master cylinder is piped to two ducts E in the body and thence by ports F to the cylinders. Steel balls retained in pockets in the ends of the masses co-operate with ports F to form distributing valves. The front end of the forward mass is bored to accommodate a helical spring constraining the mass to close port F to the forward cylinder. Each cylinder is piped by way of a port G to its respective brake actuating cylinders and is also furnished with a return duct H controlled by a ball check valve.

The cross sectional areas of ports F are such that at low rates of deceleration the pressure applied to the front brakes is lower than the master cylinder pressure owing to the action of the spring. As the deceleration rate increases, the loadings on the forward and rear masses are respectively reduced and increased until the brake actuating pressures are substantially equal. With further increase in deceleration rate the spring is balanced while the rear mass progressively increases the pressure drop in the line to the rear brakes. *Patent No.* 707372. *Gyreacta Transmissions Ltd.*

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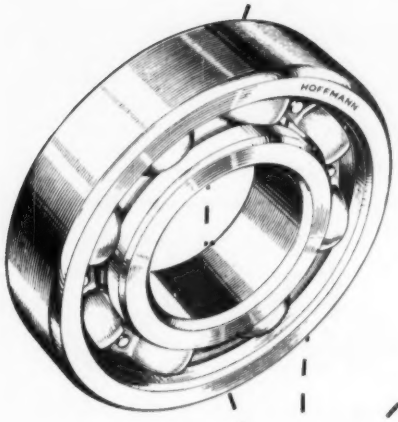

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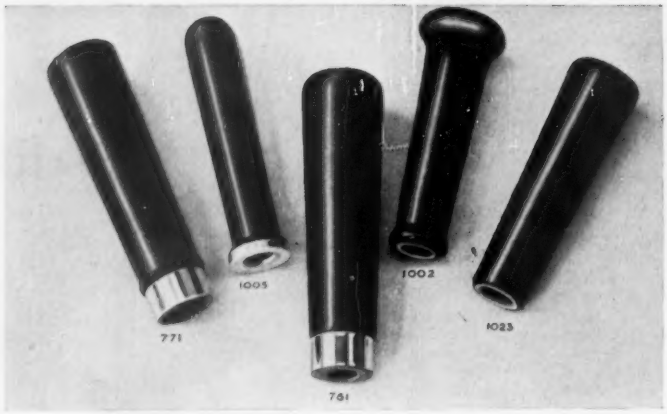

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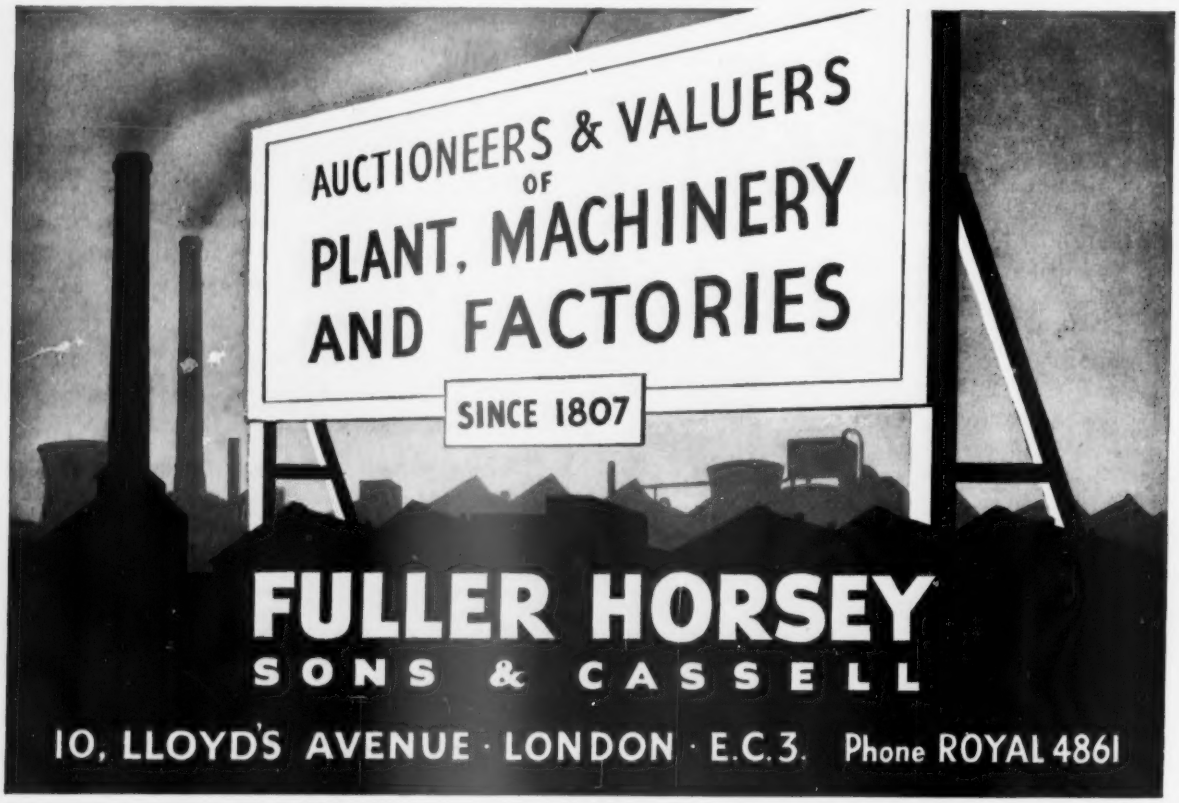
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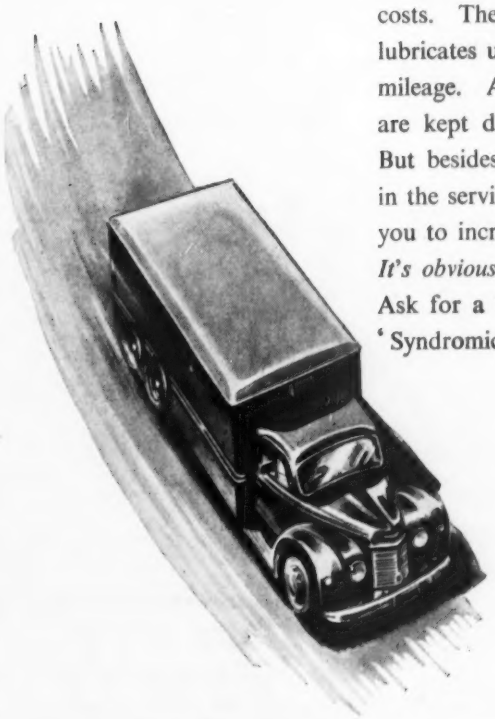

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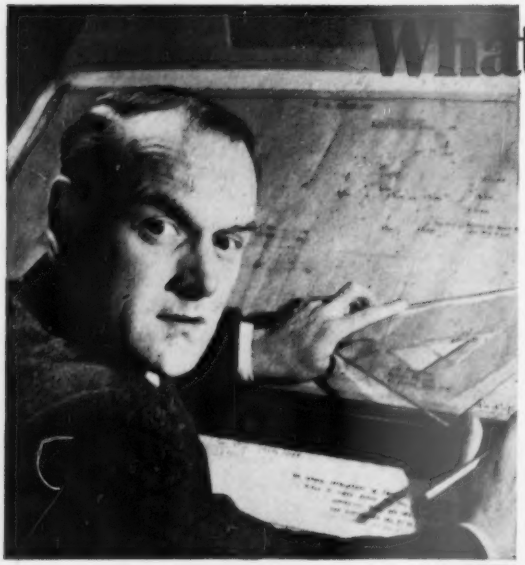

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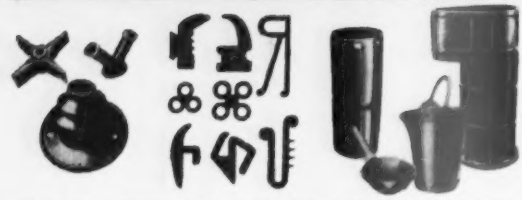

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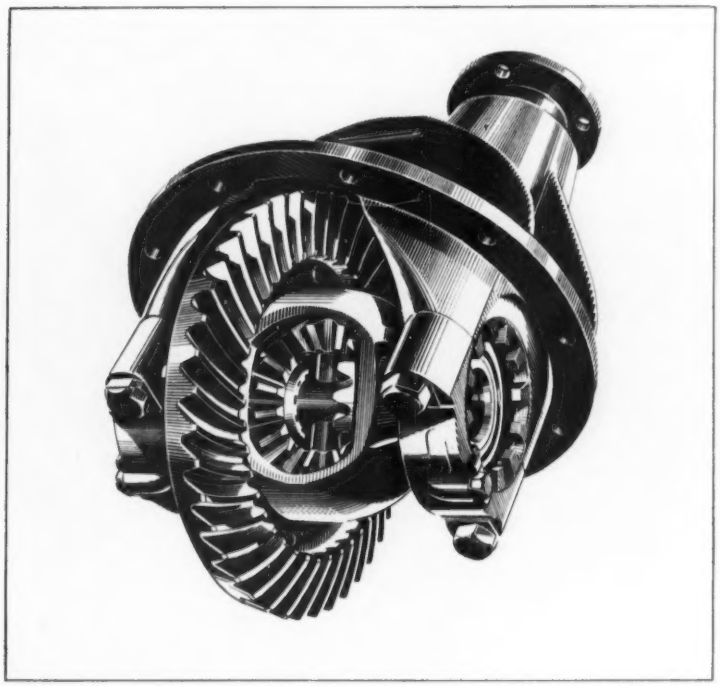

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Illustration left: A standard 5kW unit, for brazing carbide tool tips.

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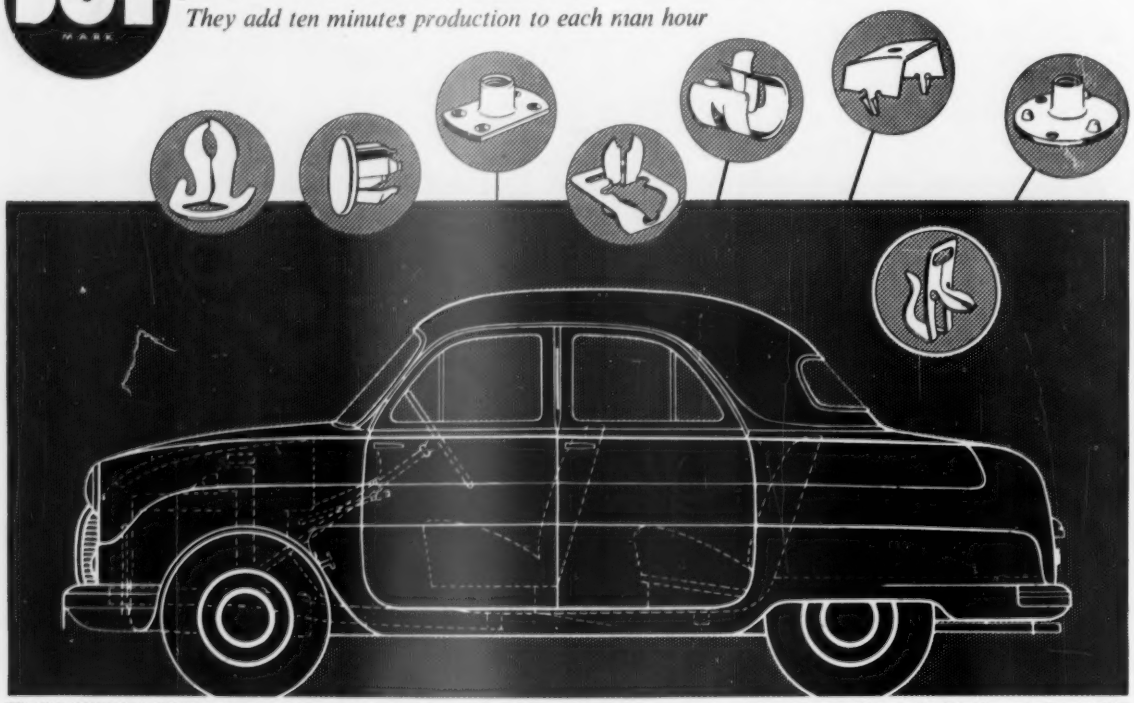

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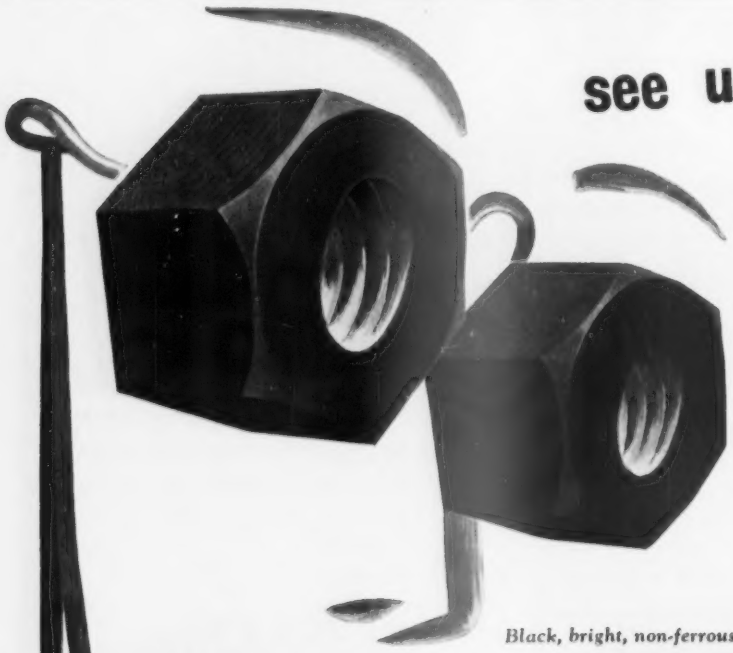

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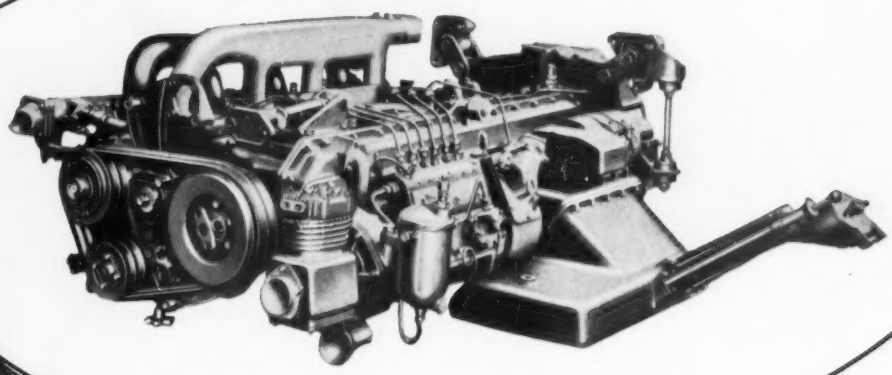

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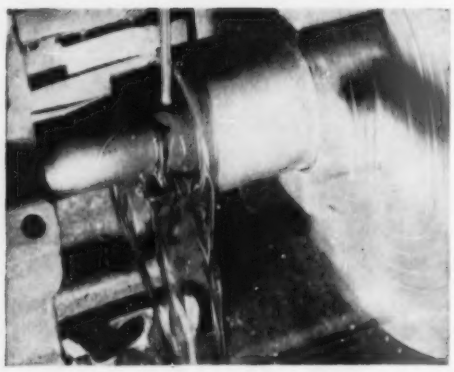

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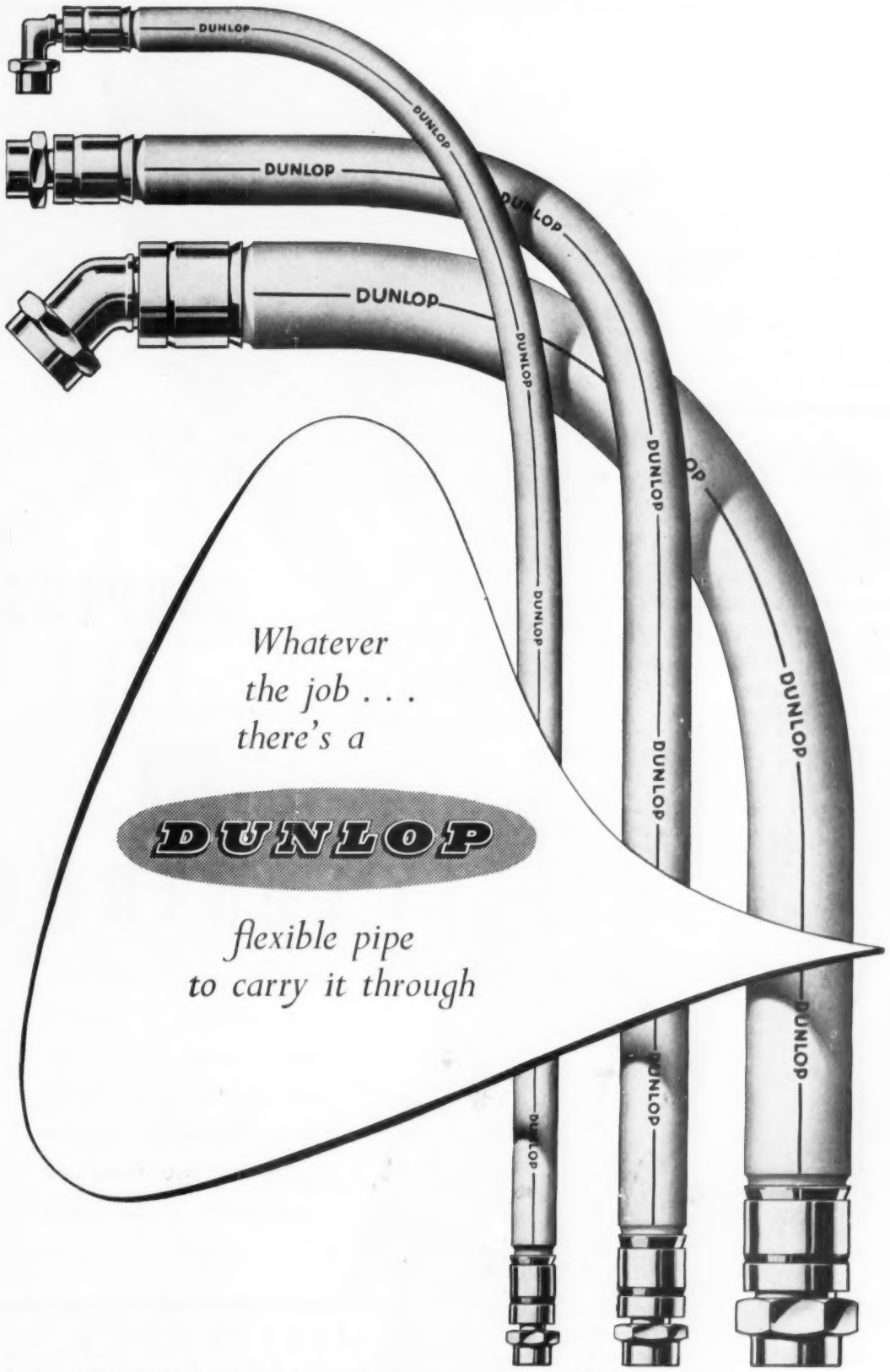
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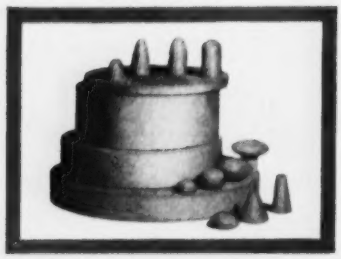

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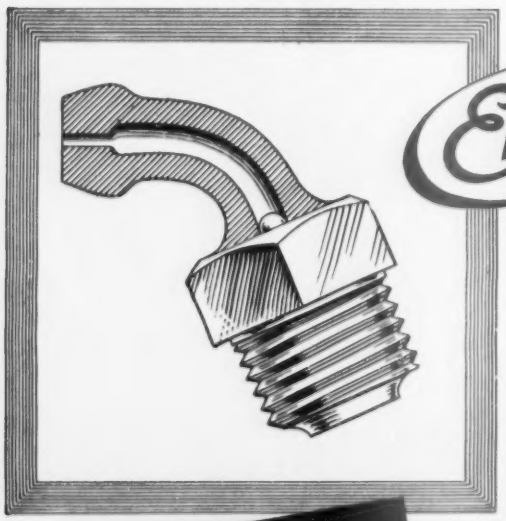

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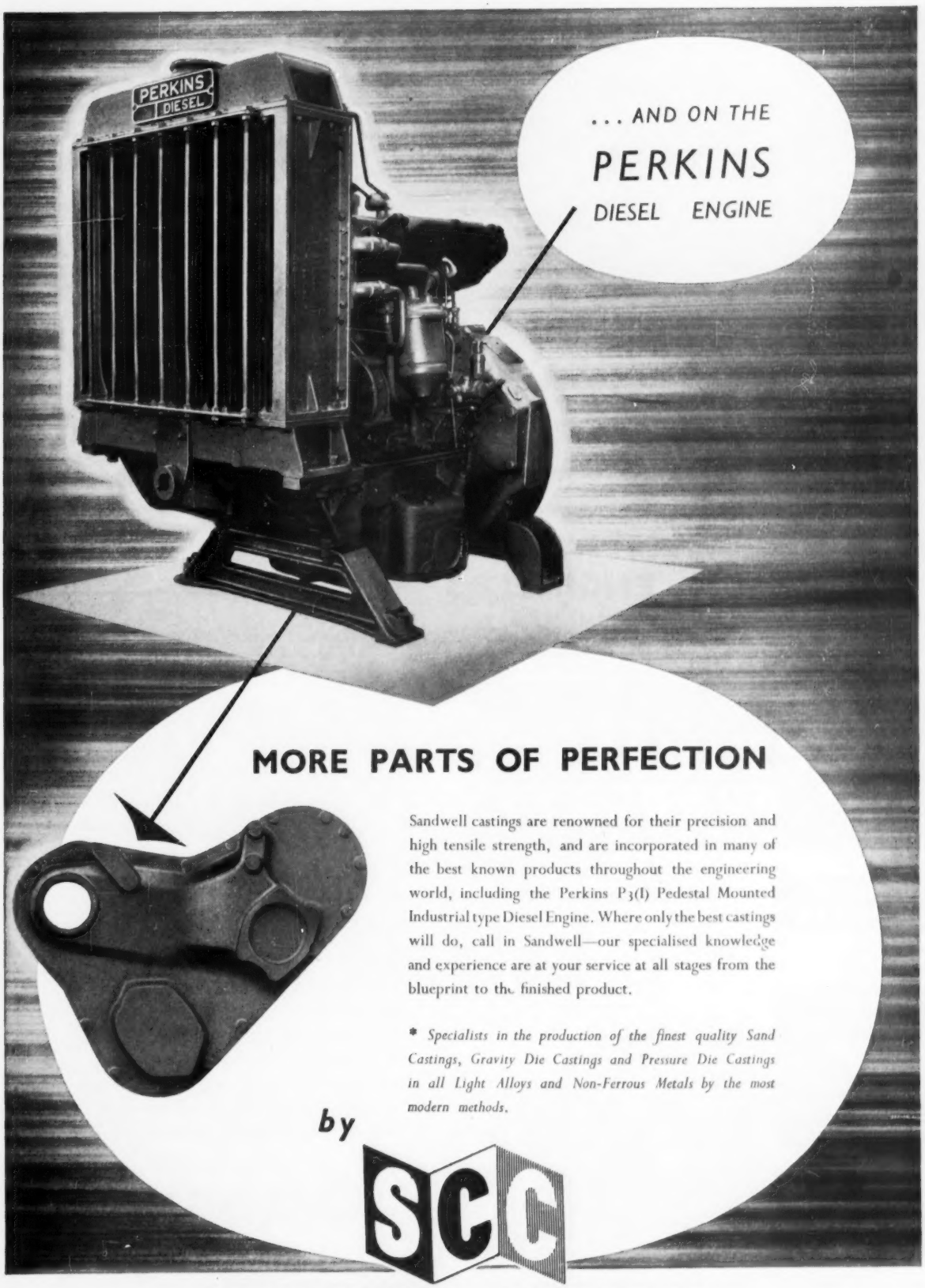

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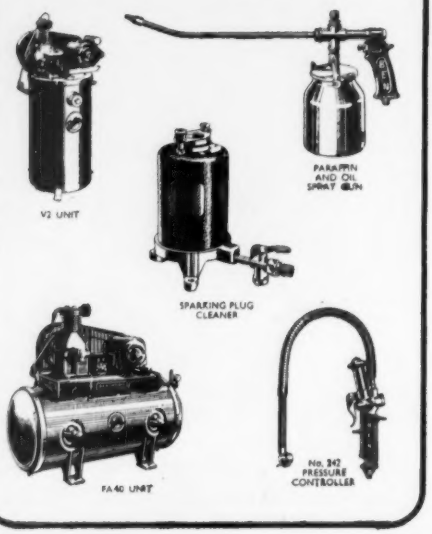

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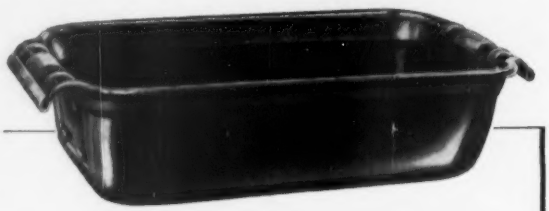

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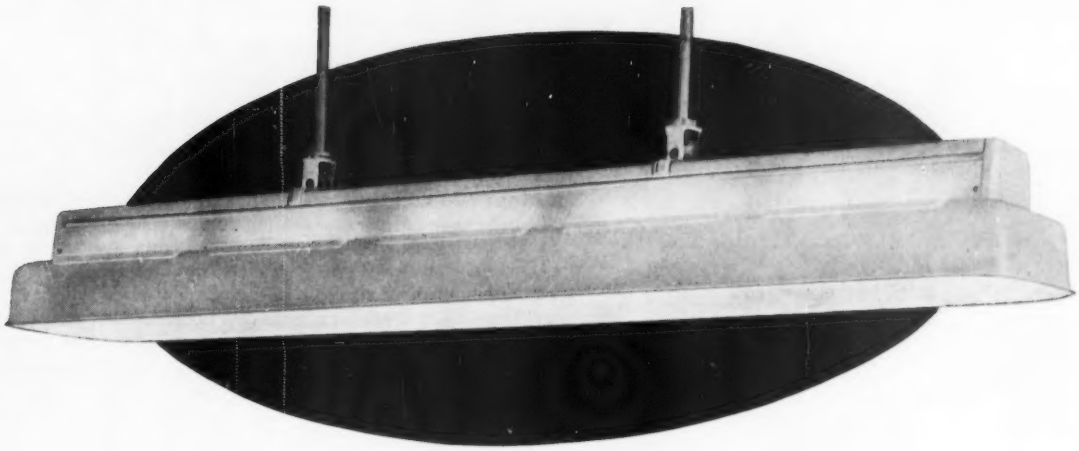

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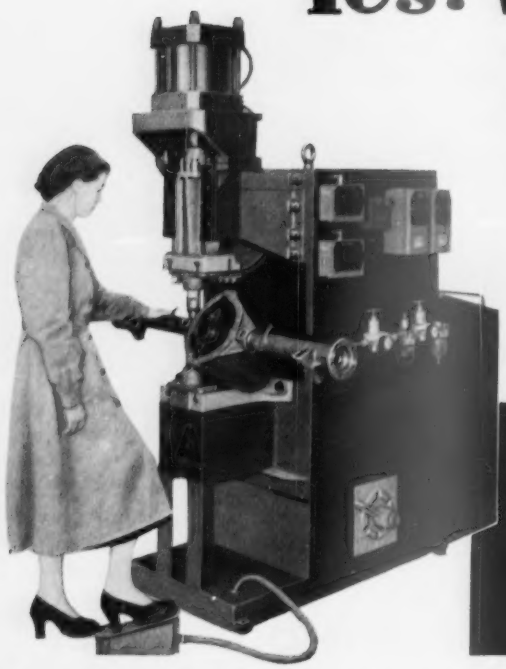

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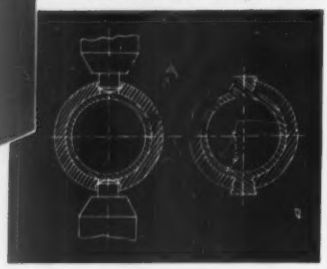

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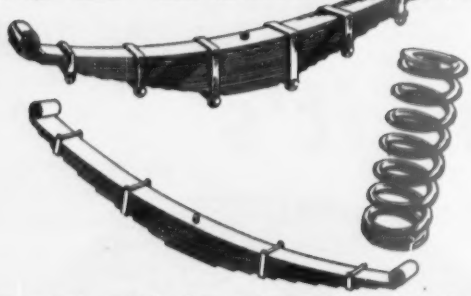

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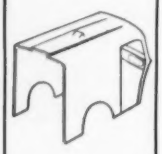

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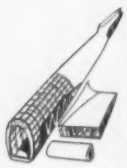

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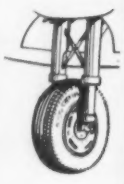

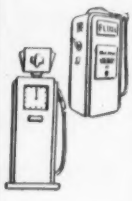

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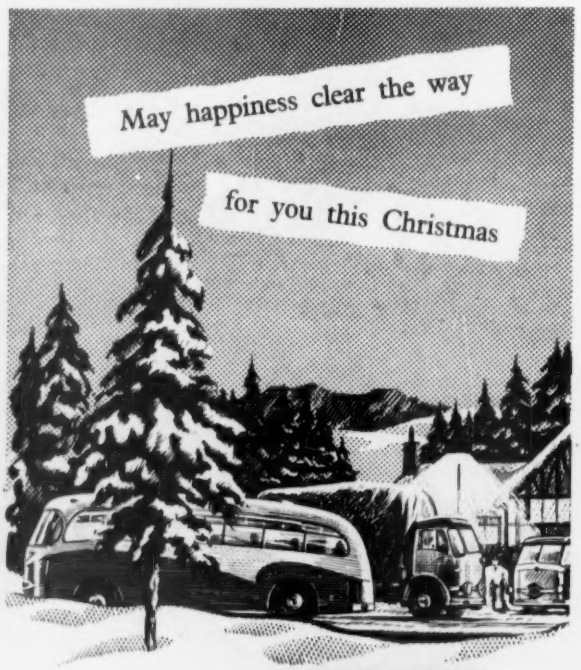

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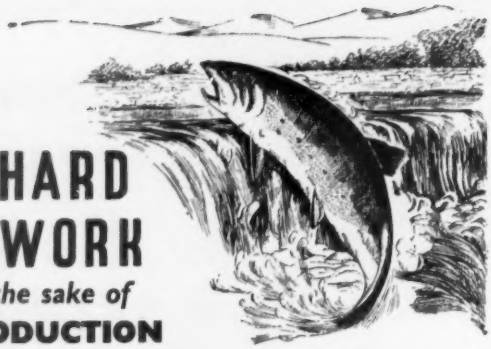

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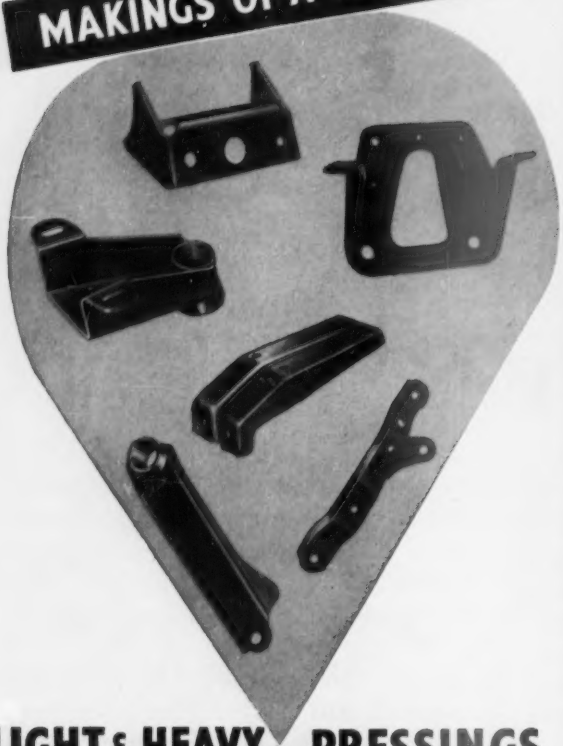

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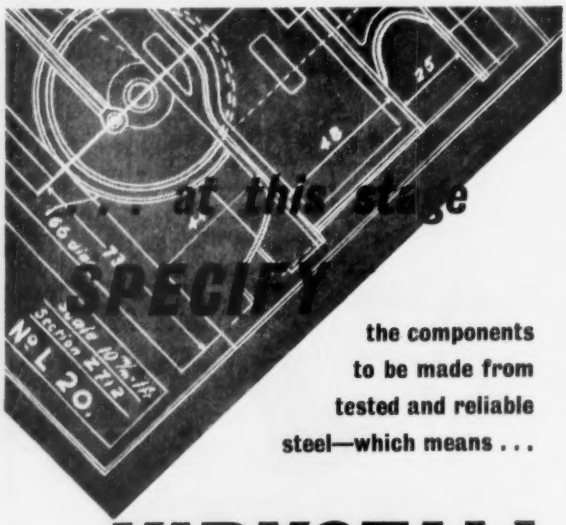

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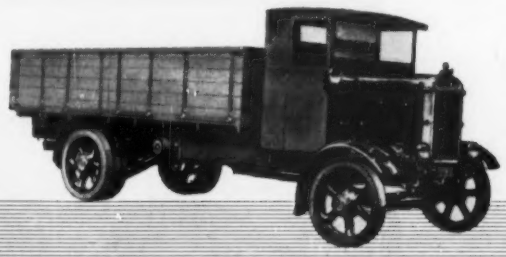

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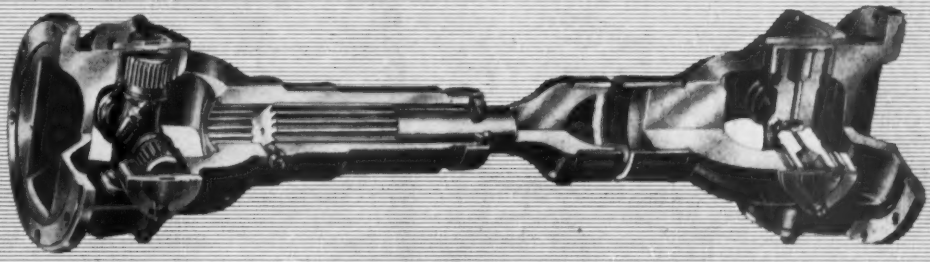

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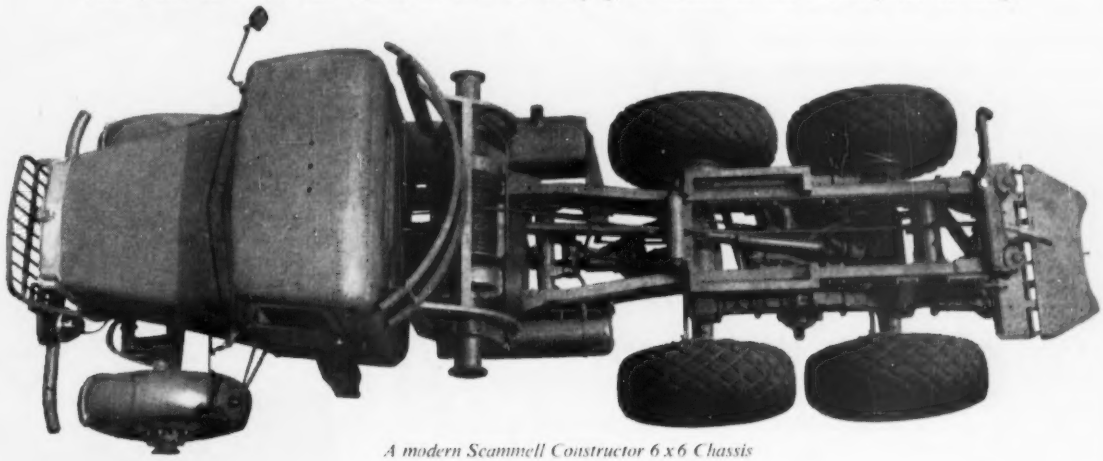

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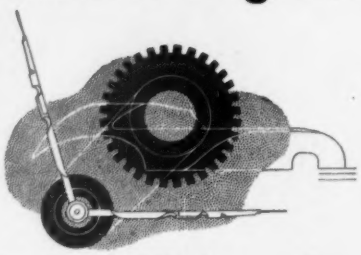

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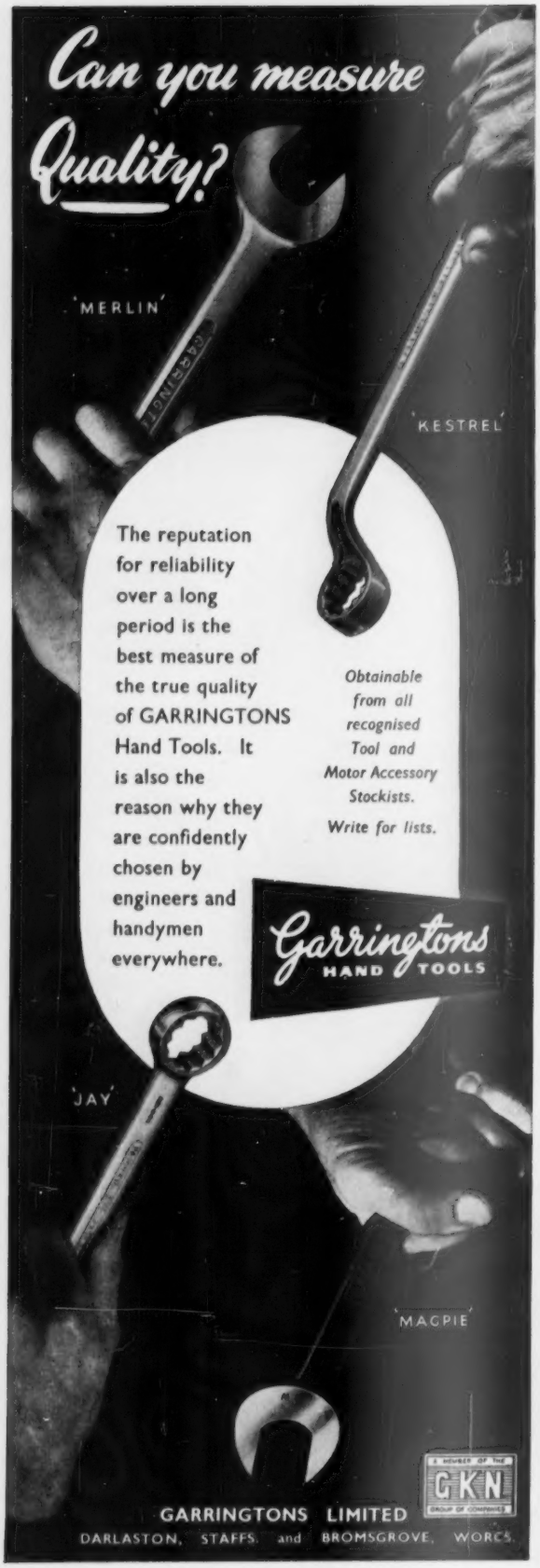
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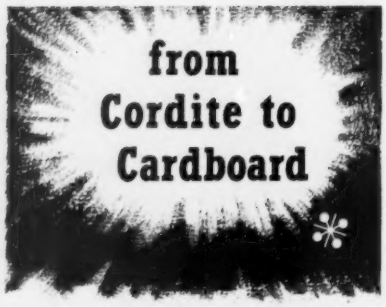

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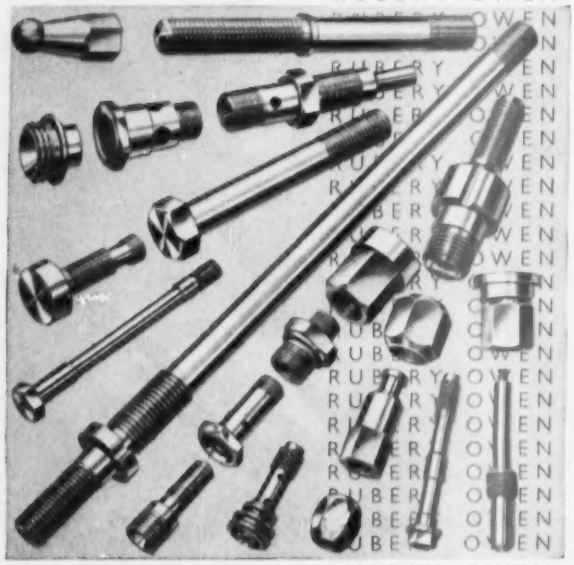

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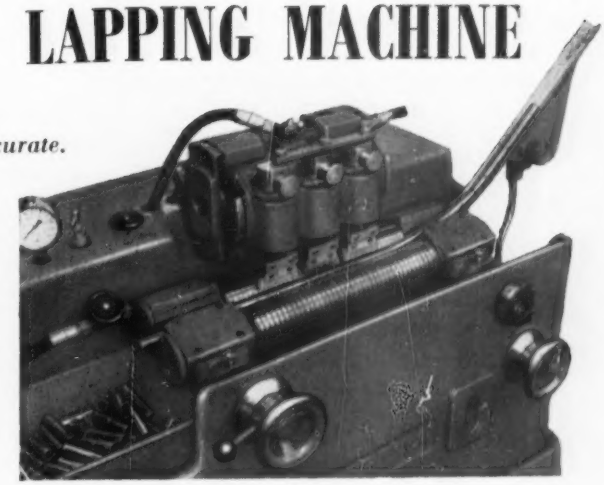

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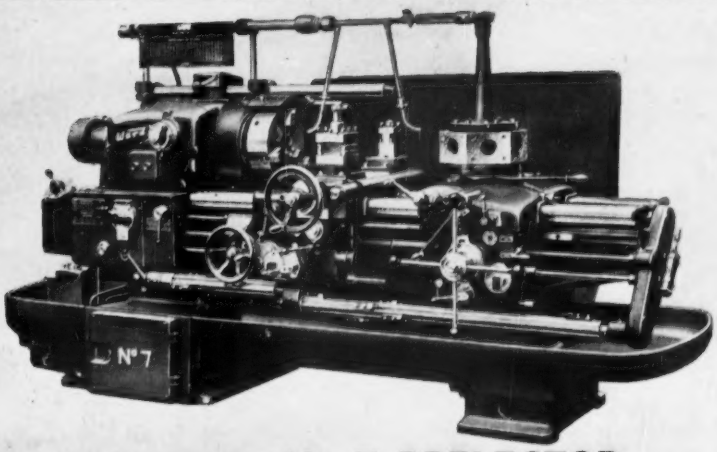

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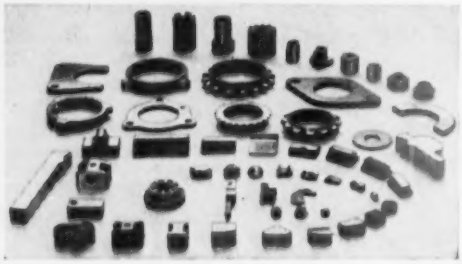

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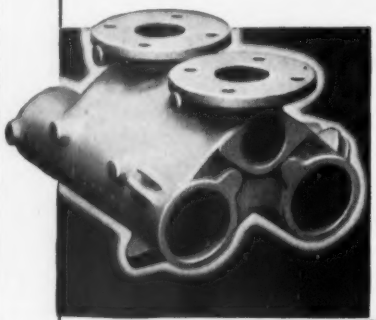

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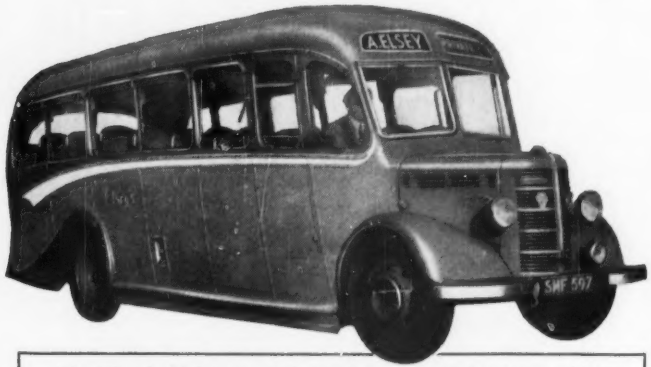

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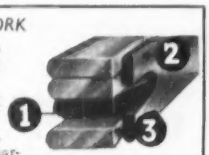

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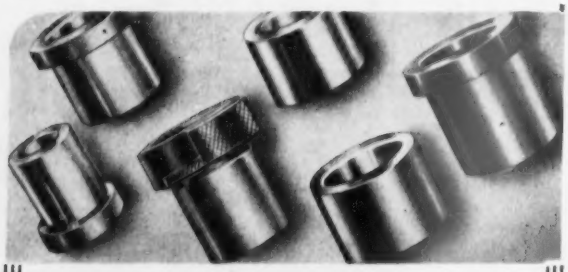

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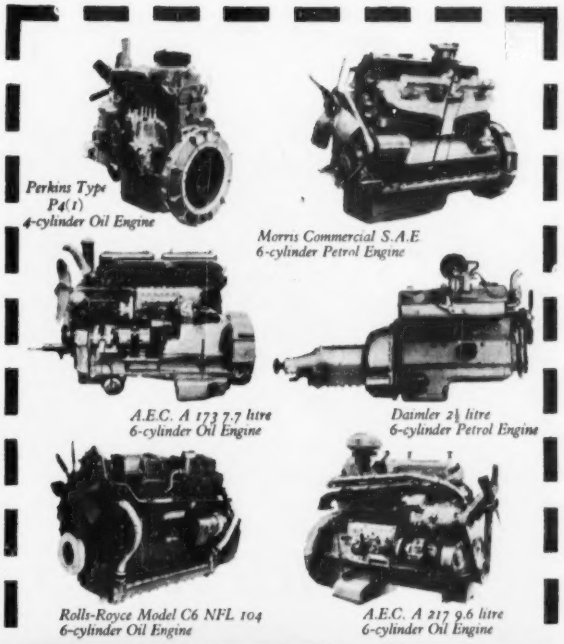
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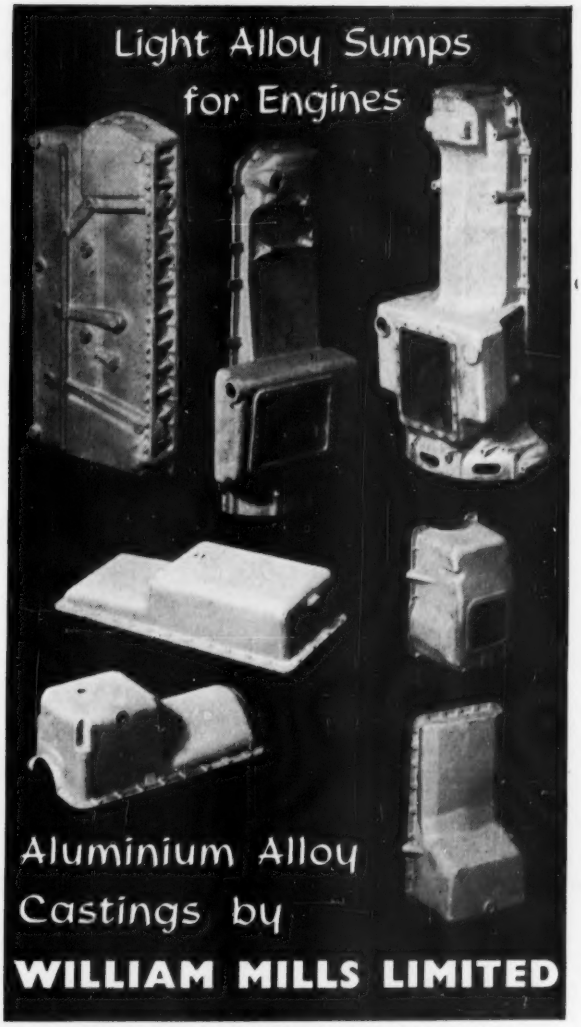

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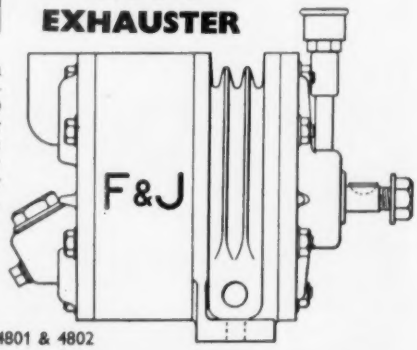

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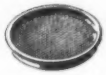
for over 25 years  in the production of filters strainers

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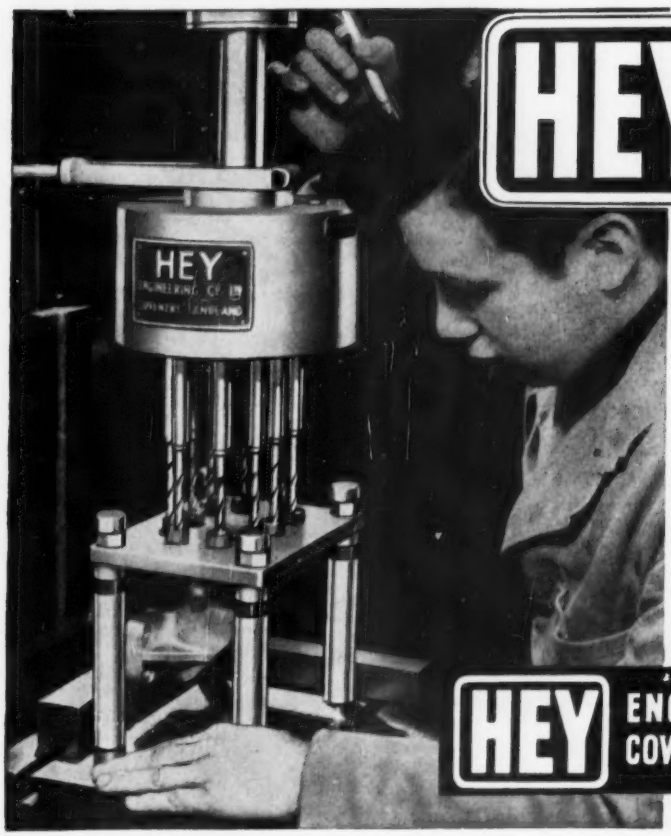

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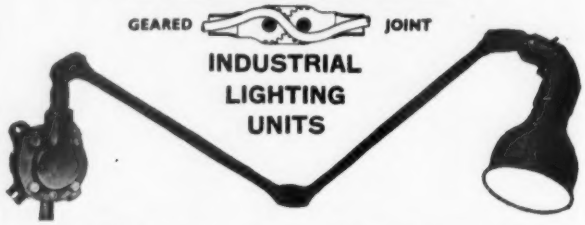

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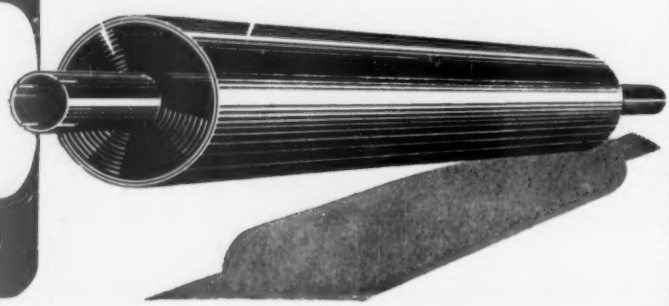

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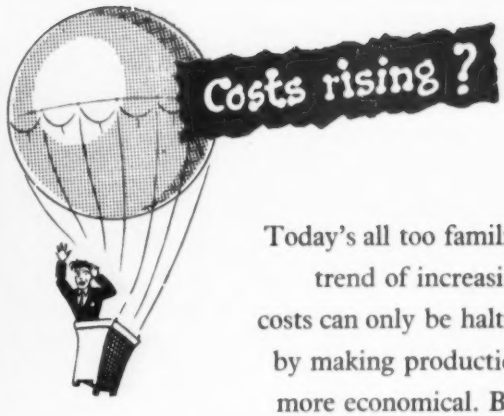

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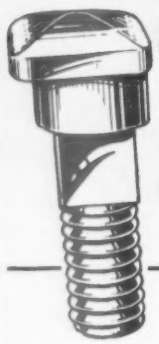

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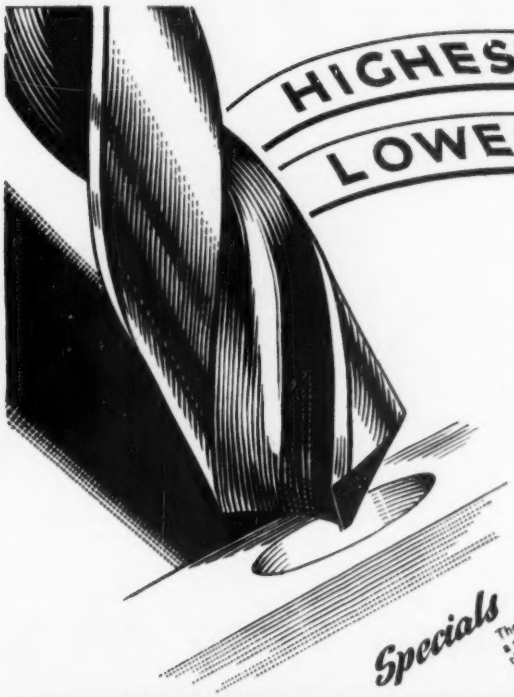

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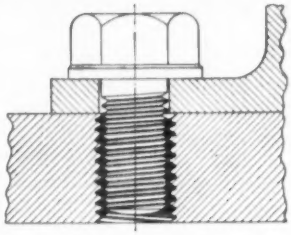

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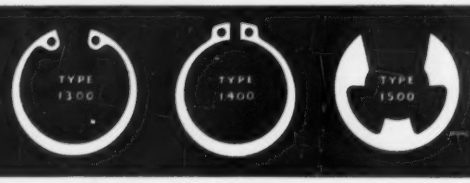

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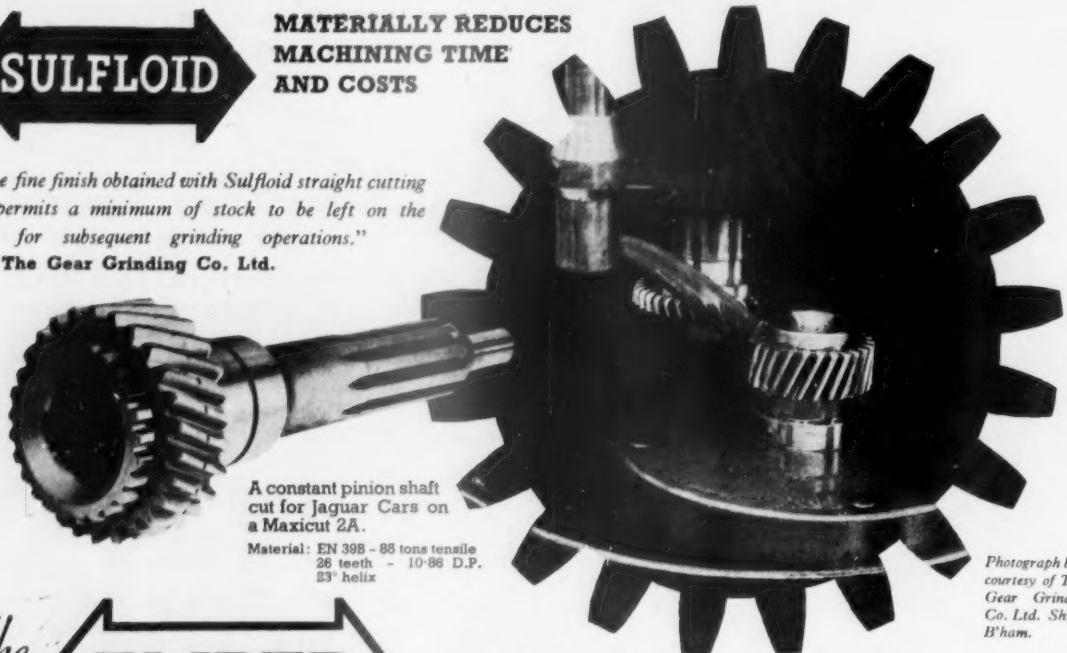

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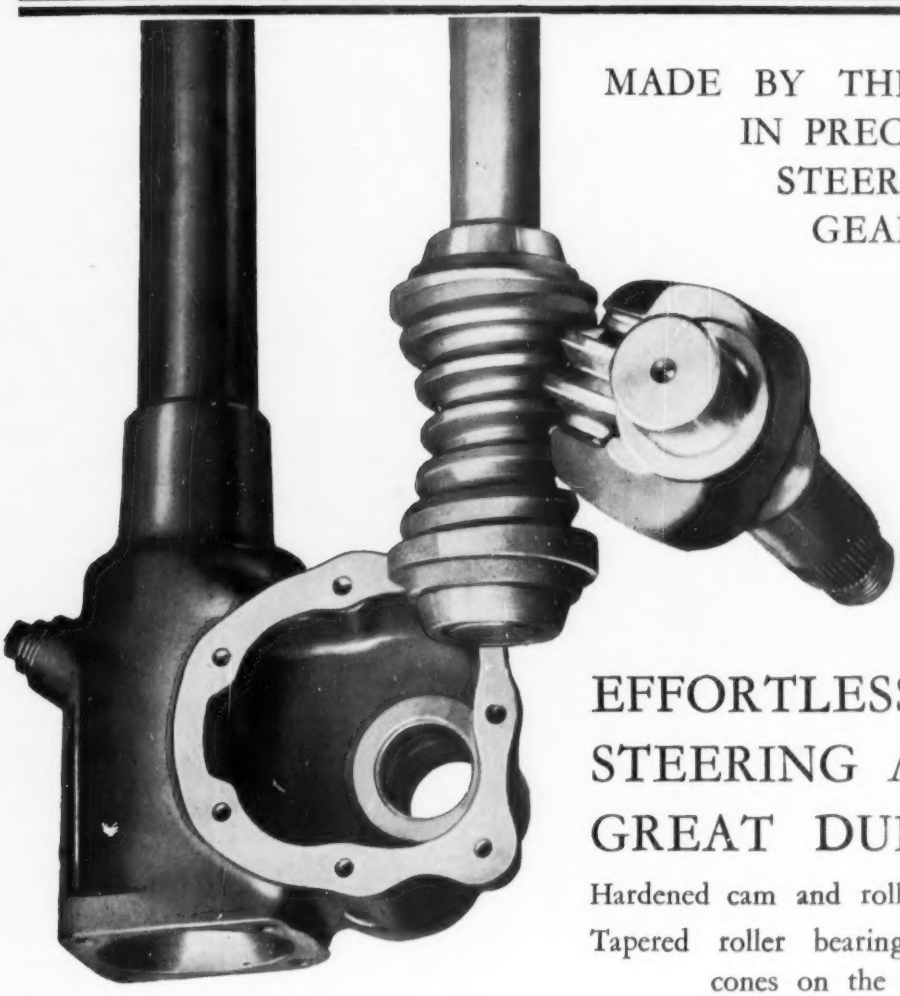

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